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DYNAMO ENGINES.

VISITORS to the Colonies Exhibition will have noted the disappearance from the electric light shed of the high speed engines which last year figured so conspicuously in driving the dynamos. Amongst those we remember to have seen driving machines direct were the Coalbrookdale engines attached to the Gülcher dynamos, the Willans to Crompton's machine, the Chandler to Siemens, the Tower to Elwell-Parker, and for the lighting of the gardens the compound engines of Goodfellow and Matthews attached to the large Siemens machines. Of these the last named alone remain and they are kept by the contractors as spare plant to be used only in the case of an emergency.

Although some of the engines mentioned behaved well during the Exhibition, others did not, and those of our readers who were frequent visitors will remember how often the cylinder or slide jacket covers were removed and daylight thus allowed to penetrate into those so-called *closed* engines. They will also be prone to compare the smooth working of the Paxman and Galloway engines now employed with the rapid and feverish performance of some of those which occupied their place a year ago.

Unfortunately, engineers are divided in their opinion as regards high and low speed engines. Some declare against the use of high-speed engines under any circumstances, while others as emphatically pronounce in their favour and fail to discern in them any defect whatever. The truth is, that the choice of an engine like the choice of most other things must depend upon circumstances; while one class of engine might serve our turn under one set of conditions, under another set it might be quite unsuited for our purpose. That quick-running engines have worked in many cases most successfully is an undoubted fact, and it is our belief that the bulk of the failures which have occurred are to be attributed simply to engineering defects and to ignorance of the principles which should guide the designer in constructing engines of this class.

Durability and economy of fuel are amongst the most important questions relating to this subject. As regards the former it is certain that with good proportion, efficient lubrication, and careful adjustment of the wearing surfaces to the strains to which they are subjected, high-speed engines can be made durable; but at the same time we think there is a limit to the speed which must soon be reached, more particularly in the case of the larger sizes where the reciprocating parts are necessarily heavy. Mr. Arthur Rigg in his paper read before the Society of Engineers, remarks that of late an opinion seems to have grown that because small high-speed engines are run with satisfactory results at speeds exceeding 200 revolutions per minute, therefore the same engines may be driven far faster with equal success; an opinion which has been partly fostered by the requirements of electrical engineers and which has led to a series of disasters of a character most discreditable to our national reputation for engineering skill. Mr. Rigg proceeds to specify the conditions which ought to be observed in designing high-speed engines, and gives diagrams and particulars of several engines which he has designed and which have been working successfully for some time. In the Allen engine introduced into this country some years since, the speed was maintained continuously at 200 revolutions per minute, the piston having a 24 inch stroke and an average velocity therefore of 800 feet per minute. This engine worked quietly and without pounding, the whole secret of its successful performance lying in the balancing and in the careful adjustment of lead and compression to the weight of the engine's reciprocating parts.

It is of the utmost importance in quick-running engines that the cushioning of the steam be such as to bring the piston gradually to rest at the end of the stroke without straining the crank pin, and a simple calculation enables the engineer to determine approximately the pressure to which for any speed and weight of reciprocating parts the steam should be compressed. Taking the Allen engine with its stroke of 24 inches and its reciprocating parts weighing 470 lbs., that there may be no strain on the crank pin, when the piston arrives at the end of its stroke it must experience a resistance to motion of nearly 6,400 lbs. which, taking the area of the cylinder at 113 inches, corresponds to a steam pressure of about 57 lbs. per square inch. Unless the entering steam is above this pressure the piston will be dragged on by the crank pin, and not until it has completed part of its stroke will its forward motion be due to an excess force on the steam side of the piston. The liability to knocking in high-speed engines with light loads is well known, and it is satisfactory to know that it can be cured by careful attention to the points to which we have referred. The reciprocating parts ought to be as light as possible, the compression ought to be independent of the load, and the engine should never be throttled, the steam supply being adjusted to the requirements of load by an early or late cut-off. These conditions are more or less perfectly fulfilled in the best high-speed engines, lightness of reciprocating parts being secured in some types by making the pistons, connecting rods and valve spindles hollow.

It may be mentioned that our ideas of engine speed are liable to some confusion from the fact of our talking of piston speed rather than of the number of reciprocations per minute. In all cases the piston speed increases with the size of the engine, although the number of revolutions diminishes, and it is the latter which is of importance in this consideration. Thus the Westinghouse engine indicating 2 horse-power makes 600 revolutions with a piston

speed of 300 feet per minute, while that indicating 130 horse-power makes 275 revolutions with a piston speed of 687 feet. Willans' engine, indicating 3 horse-power and running at 900 revolutions, has a piston speed of 450 feet, while the 100 horse-power engine runs at 400 revolutions with a piston speed of 600 feet. Both these engines are single acting, but the same remarks apply to double acting engines of the "Invincible," "Allen" or other reciprocating high-speed type.

Before comparing the merits of single-acting and double-acting engines, we would refer to a matter of some importance as regards the driving of dynamos direct. Our readers are aware that in every reciprocating engine the power is delivered to the shaft in the form of intermittent pulsations, and when driving dynamos direct the power is of course transmitted in this form to the armature of the machine. In belt driving the power is delivered to the dynamo spindle with much less variation, due doubtless to the irregularities being taken up by the elasticity of the belt and by any slip which may occur. Armatures, which until lately, were regarded as models of mechanical stability, have in several instances hopelessly broken down when direct driving has been employed, and we cannot too strongly advise the use of a flywheel placed between the dynamo and the engine whenever the two are coupled together. The flywheel does not alter the form in which the power is delivered to the crank-shaft, but it reduces greatly the periodic strains on the armature supports and substitutes instead of those an intermittent twist on the shaft between the cranks and the flywheel. It is probable that transmitting the power to the dynamo through a flexible or spring coupling as in the case of gas engines would prevent the destruction of the armature, but if we have in the engines a turning moment which is approximately constant during the whole of the revolution, the necessity for this contrivance is of course avoided. By a careful adjustment of the weight of the reciprocating parts to the speed, load, and grade of expansion, this approximate uniformity can be secured.

The same precautions as regards cushioning must be adopted in both single and double acting engines, and it appears that in the working of these two classes there is little to choose between them. In all high-speed engines the strains of a dynamic character depending upon the motion of the different parts are of immense importance, and the rotatory and reciprocating masses ought to be balanced as perfectly as possible. With this end in view the cranks in twin-cylinder double-acting engines are placed opposite each other, but it is necessary notwithstanding that each piston shall have the compression properly adjusted to its speed and weight. If this point is overlooked, it is just possible that the twin-engine might be, owing to the surging of the two heavy weights at opposite angles, more out of balance than a single engine. The cylinders ought to be kept as close together as possible in these engines in order to reduce the moment of this deleterious couple. Single-acting engines are heavier for a given amount of work than those which are double-acting, and the latter have the additional advantage of impelling the piston in both directions with a single cylinder, while to get a motion as uniform from a single-acting engine two cylinders must be employed. With large wearing surfaces the double-acting engine will doubtless run for long periods without any readjustment of the connecting rod brasses, but the single-acting engine has the advantage of the wear being taken up by the engine itself, its rods being always in compression. From the fact of trunk pistons being employed, it is possible to get a longer connecting rod in the latter for the same head room, but on the whole we think the two classes are about equal in merit everything considered.

We have said that high-speed engines can be made durable, but durability is after all a question of degree. We do not think for a moment that engines running at great speed can be compared in point of durability with slow-speed engines, and any data that would alter our conviction, if it exists, is very difficult to get hold of. We have a rooted antipathy to anything over six hundred revolutions per minute in engines, and our ideas are such as prompt us to advise slower speed engines, and belt or rope driving in every case where what we believe to be the only important advantage of direct driving, namely, compactness, is not a desideratum. With high speed the wear is certainly greater than with low speed, and to imperfectly neutralised dynamic strains combined with high velocity this must be attributed. In slow-speed engines like those at the present Exhibition, these dynamic strains are unimportant, accurate balancing is not necessary, and some approximation, sufficiently near the mark for practical working, is found in loading the crank disc, or in putting the cranks at opposite angles. The Paxman coupled engines at the Exhibition have a cylinder diameter of 18½ inches with a stroke of 32 inches and run at 72 revolutions per minute; the Galloway compound engines have cylinders of 15 and 26 inches and run at 100 revs. with a stroke of 30 inches. The former corresponds to a piston speed of 384 feet per minute, the latter to 500 feet.

It is to be regretted that information regarding fuel and water consumption in high speed engines is so difficult to obtain; it is still more to be regretted that some, having in view the excessive consumption of one or two particular types, brand all alike with the opprobrious epithet of "steam eater." Although in high speed engines generally, for some reason or other, the consumption of water and coal has not been reduced to the amount required for slow-speed engines, yet very satisfactory results have been obtained from time to time with some of them. We are not prepared to place much confidence in the accuracy of indicator diagrams taken from high speed engines; we much prefer tests with an absorption dynamometer, and we trust that when comparative tests are to be made this method of comparison will be adopted. From tests made with the Westinghouse engine we find that the steam used was 34·36 lbs. per I.H.P. per hour, or 38·8 lbs. per brake H.P., the coal used being 5 lbs. per I.H.P. per hour. In the tests of the Willans compound engine to which we referred a short time ago, the steam used per I.H.P. per hour was 23·2 lbs., a very satisfactory result when compared with those obtained from slower running engines. With an evaporation of 9 lbs. of water this is equal to a consumption of 2·6 lbs. of coal per I.H.P. The compound triplex engine, by Goodfellow and Matthews, is said to consume from 2·5 to 3 lbs. of coal, but whether in these cases the same results would be obtained from runs extending over a long period we are unable to say. The Paxman engines at the Exhibition show in the compound non-condensing class a consumption of fuel of from 2·2 to 2·3 lbs. per I.H.P., the steam used being from 21 to 22 lbs., and this result extends over a long period. In the compound condensing class the consumption of fuel is under 2 lbs., and the steam is reduced to 18 lbs. Both these classes have a boiler pressure of 115 lbs. per square inch. In the non-compound non-condensing class the pressure is 95 lbs. per square inch with a cut off at ⅜ths stroke, and the consumption of fuel is 4½ lbs. per I.H.P., the steam used being 42 lbs. The evaporative power of the steel loco-type boilers is equal to 9 lbs. of water per lb. of Welsh coal at 20s. per ton, and our readers from this will be able to see how much they have to pay for each watt appearing in the lamp circuit when the dynamo gives 70 per cent. of the I.H.P. of the engine. In conclusion we may state that these engines are worked with the steam valve full open, the grade of expansion being regulated by the governor in conjunction with automatic slide gear. We are assured by Mr. Paxman that when the load is suddenly and completely removed the increase of speed is not more than 2 per cent., and we hope to have a chance of verifying most of the above data for ourselves shortly.

Postal and Telegraph Reform.—At the forthcoming conference in connection with the Colonial and Indian Exhibition, "Postal and Telegraph Reform" is amongst the topics set down for discussion.

THE INCANDESCENT LAMP PATENT CASE.

WE have now reported in these columns much of the evidence and the judgments on two of the most important trials which have ever taken place with regard to the subject of electric lighting.

Taking into account the difficulty of the questions involved, and the magnitude of the interests at stake, we believe that we shall be doing a service to our readers if we endeavour to analyse these judgments; not pronouncing a definite opinion upon them, but rather endeavouring to determine clearly what has been decided, and what effect the decisions will have on the manufacture of electric lamps in the future.

The actions were brought by the amalgamated companies owning the Edison and Swan patents against Messrs. Woodhouse and Rawson, the well-known makers of incandescent lamps.

In the first action three patents were sued upon, viz.: 4,576, of November 10th, 1879 (Edison); 18, January 2nd, 1880 (Swan); and 4,193, of September 29th, 1881 (Gimingham).

With regard to the second of these, it may be briefly described as a patent for the operation of "running on the pumps," as applied to carbon lamps. This, there is no doubt, would have been held void for want of novelty, had the matter been pressed to a decision; but in the course of the case the counsel for the plaintiffs really failed to bring any evidence that such a process had been used by the defendants. This seems to have been in reality no oversight, for by this means a decision on the patent was avoided. Had the validity of the patent come in question, it would in all probability have been upset, on the ground that in a previous patent of Edison's, June 17th, 1879, No. 2,402, the very same process is described for the removal of the occluded gases in metal filaments, with the intimation that "carbon sticks may also be freed from air in this manner." Quite apart, therefore, from any other anticipations, the above-mentioned patent of Edison seems to disprove the novelty of Swan's patent. It may, perhaps, be a matter of wonder that (Edison owning the patent) the plaintiffs did not sue upon it. But the patent itself was weak for other reasons, and, moreover, only claimed running on the pumps as applied to metal filaments. It was, therefore, clearly useless as a weapon of offence, and only served to destroy Swan.

Gimingham's patent consisted in the flattening out of the platinum leading wires, and drawing them through a plate so as to make a socket, similar to that which holds the lead in pocket pencils. This also would probably have been held invalid for want of novelty; but here, also, the evidence of infringement given by the plaintiffs was of so shadowy a character that by their own consent the patent was not pushed, and a verdict thereon, as well as for the patent of Swan, passed for the defendants.

On the other hand, the patent of Edison was upheld, and the decision is so interesting that it is well worth a careful analysis.

The patent substantially is as follows:—"It is essential that lamps should be of great resistance . . . . In patent, 1879, 2,402, I have set this forth and obtained lamps of great resistance by employing long lengths of platinum wire. . . . . My present invention relates to lamps of a similar character, except that carbon threads or strips are used instead of metallic wires. . . . . Heretofore, light by incandescence has been obtained from rods of carbon of one to four ohms resistance, placed in closed vessels in which the atmospheric air has been replaced by gases that do not combine chemically with the carbon . . . . the connection between the leading wires and the carbon has been obtained by clamping the carbon to the metal. The leading wires have always been so large that their resistance shall be many times less than the burner, and, in general, the attempts of previous persons had been to reduce the resistance of the carbon rod. The disadvantage of following this practice is that a lamp having but one to four ohms resistance cannot be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions, that owing to the low resistance of the lamp the leading wires cannot be of large dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires are passed in and cemented, hence the carbon is consumed because there must be almost a perfect vacuum to render the carbon stable, especially when such carbon is small in mass and high in electrical resistance. . . . . I have reversed this practice; I have discovered that even a cotton thread, properly carbonised and placed in a sealed glass bulb exhausted to one-millionth of an atmosphere offers from 100 to 500 ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures. But if the thread be coiled as a spiral and carbonised, or if any fibrous vegetable substance which will leave a carbon residue after heating within a closed chamber be so coiled, that as much as 2,000 ohms resistance may be obtained without presenting a radiating surface greater than $\frac{3}{16}$th inch." The inventor then goes on to describe carbon filaments made of tar and lampblack kneaded and drawn out into threads, wound into spirals and carbonised, and to suggest the introduction of volatile powders into this filament to increase its resistance.

He then describes a method of uniting a filament to platinum wires, by moulding plastic lampblack and tar round the joints, and afterwards carbonising them, and goes on to say that cotton and linen thread, wood splints, paper coiled in various ways, and lampblack, plumbago, and carbon in various forms, and kneaded with tar, may be made into wires of uniform thickness. He describes a method of winding the spirals on copper to prevent distortion during carbonisation, and dissolving away the copper afterwards by means of acid.

He claims:—

First—An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance made as described, and secured to metallic wires as set forth.

Second—The combination of a carbon filament within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted for the purposes set forth.

Third—A coiled carbon filament or strip arranged in such a manner that only a portion of the surface of such carbon conductor shall radiate light, as set forth.

Fourth—The method herein described of securing the platina contact wires to the carbon filament, and carbonising of the whole in a closed chamber substantially as set forth.

At the trial it was admitted that the defendants had made a certain lamp, one of those so well known that we need not describe it. It consisted of a thin thread of carbon fixed to platinum wires, sealed into an exhausted globe wholly of glass. As a matter of fact, its resistance was about 60 ohms; but this did not very clearly appear at the trial.

Every manner of objection was taken to the patent in the pleadings (as is usual), but substantially the defence was that as to the first claim, the defendants did not infringe it, for it was not shown that they made the filament "as described," or secured it "as set forth;" as to the second claim, that the combination thus described was old.

As to the third claim, that the coiled carbon filament was also old. The fourth claim was admitted not to be used by the defendants, but no evidence seems to have been offered that it was old.

In the evidence at the trial it was shown, as before said, that the defendants did not make their carbon filaments as described. On the contrary, that they made them by a private process of their own, which they declined to reveal. Therefore, in the absence of evidence that they were made "as described," on this point the judgment was that the first claim was not shown to have been infringed. As to the second claim, it was admitted that a lamp made by Swan, and consisting of a slender stick of carbon, about as big as the carbon of a lead pencil, and attached to platinum

wires, and sealed in a globe consisting wholly of glass, had been publicly exhibited before the date of Edison's patent. It was further proved that Sidot had proposed the carbonisation of strips of wood, thread and silk, by means of heat, and had suggested their use for electric lighting, but whether for arc or incandescent use did not clearly appear. It was also proved and not disputed that carbon sticks and pencils had been long in use in vacuo for incandescent lighting (though this did not carry the case further than it was carried by Swan's anticipation), and it was also shown that two inventors, Pulvermacher and Van Choate, had proposed carbon spirals, one to make a sort of electric candle and the other for use for electric lighting, which appeared pretty clearly from his patent to be electric lighting of the "incandescent" order. On these grounds the defendants argued that the word "filament" had been nowhere clearly defined by Edison, that he had not shown where a "stick" ended and a "filament" began, that it was no new invention merely to put a thin Sidot "thread" in a "Swan" lamp, and that the previous anticipations by Pulvermacher and Van Choate of the third claim to carbon "spirals" vitiated the whole patent. Morever, it was shown that metallic spirals were in previous use, as also carbon sticks, pencils and rods, and it was argued that it was no new invention merely to make a carbon spiral. A vast mass of evidence was given on both sides, but on a perusal it will not be found to alter the facts above set forth.

Now it will be observed that Edison nowhere points out that his filament is elastic, but only that it is of high resistance and small sectional area.

The decision of the court was that the second claim to a filament enclosed in an exhausted receiver of glass was good, and that the defendants had infringed it. In order to decide this it was, of course, necessary for the judge to decide what a "filament" was, and this proved the real difficulty of the case. Finally, he decided that by a filament was meant a carbon conductor of small cross section possessing flexibility and resilience and of high resistance. He further added that he was inclined to the opinion that the resistance should be at least over 100 ohms, but did not consider it necessary to decide that point.

With regard to this decision it may be remarked that neither flexibility nor resilience are anywhere pointed out by Edison as necessary to his filament, and as to the last, if the Court of Appeal should coincide with Justice Butt's opinion, that a resistance of at least 100 ohms is necessary to constitute a "filament," then, in that case, they will have, in all probability, no alternative but to order a new trial, or else reverse his judgment, for if this resistance be a necessary part of the notion of a filament, then not only was no proof given that the infringing lamp had that resistance, but simple inspection of the lamp produced in court showed that it could not have a resistance of more than about 60 ohms. Moreover, it will still be necessary to do what Mr. Justice Butt has as yet not attempted, viz., to define the limits at which a filament begins.

Without discussing further the eventual chances of this case, it will appear clear to the electrician that it is not so difficult to make a lamp altogether outside this patent. For if once a lamp have a filament made in a manner different from that described by Edison, or else not "secured as set forth" it will avoid the first claim, and if it be enclosed in a receiver not made wholly of glass it will avoid the second, if it be not of a spiral form it will avoid the third, and if it be not "secured as set forth" it will avoid the fourth claim. It is, of course, very perilous to prophesy, but certainly, even if the Court of Appeal support Mr. Justice Butt's judgment by rejecting a portion of the reasoning on which he founded it, it is yet within the bounds of human probability that some inventor may yet devise a lamp consisting of a filament neither enclosed in a receiver "entirely of glass" nor "secured as set forth," in which case it is difficult apparently to see how he could be attacked by the Edison patents.

(*To be continued.*)

HOW TO WIND THE MAGNETS FOR SHUNT, SERIES, AND COMPOUND MACHINES.

By CARL HERING.

VIII.—COMPOUND MACHINES *(concluded).*

THESE corrections will evidently be different in the two methods of winding. For the ordinary compound winding shown in fig. 3 (see ELECTRICAL REVIEW, May 28th), in which the shunt coils are attached to the poles of the armature, let g, h, fig. 6, represent the same line as g, h, in fig. 5. In the same way as before, determine approximately the current required for the shunt circuit and the loss of potential allowed for the series coils. Lay off o, r, equal to the shunt current (exaggerated in this diagram for the sake of clearness), then r, s, will represent the ampère turns required in order to supply the necessary current for the shunt when the machine gives the proper potential on an open circuit. The currents in the lamp circuit will, therefore, be measured from r to the right; that is, they are equal to the whole armature current, o, i, for instance, less that used in the shunt, o, r.

When the current flows through the lamps, and therefore through the series winding, the potential at the poles of the machine would fall by the amount which is absorbed by the series coils, for in the test the machine was run with constant potential at the armature. As this fall of potential increases with the current, it will have to be generated again by a corresponding increase in the number of series windings. Furthermore, as this fall of potential does not begin until the series coils begin to act, a line, s, t, drawn from, s, making a certain small angle with s, h, would represent the necessary increase of the ampère windings, in order to increase the potential at the armature, so that at the poles of the machine it may be constant. Furthermore, if the potential at the armature poles be increased, the current in the shunt will be increased, for it is connected with these poles. The question then arises how many of the ampère windings will then remain for the series coils to generate. This may be calculated as follows:—From the allowable loss of potential in the series coils at the maximum load, calculate by simple proportion what the total increased number of ampère turns must be; in other words, if the constant potential, V, volts requires h, i, ampère windings, then $V + v$ volts (v being this loss) will require $\frac{V + v}{V}(h, i)$ ampère windings. This gives the distance, i, t. Then s, t, will represent the true corrected curve which gives the true values of the ampère turns which will so raise the potential of the armature that the potential at the poles of the machine will remain constant.

The proportion of this which will have to be allotted to the series coils is obtained as follows:—Knowing the highest potential at the armature, $V + v$, and calculating the resistance, R, of the shunt coils from the potential on open circuit and the current in it, we are enabled to calculate what current will flow through it at the maximum load when the potential at the armature is $V + v$. This gives for the maximum current through the shunt $\frac{V + v}{R}$ which multiplied by the shunt windings give the ampère windings in the shunt for the full load. Therefore, if we lay this off at i, d, then it will leave d, t, ampère windings to be supplied by the series coils. Dividing this number of ampère windings, represented by d, t, by the current in the external circuit (remembering to subtract that in the shunt for d, i, ampère windings from the whole current, o, i) it will give the corrected number of windings for the series coils.

Having thus found the proper number of windings for the series coils, and having given its maximum current and its allowable resistance (from the fall of potential and maximum current), the rest of the calculation is the same as for series machines, except that in this case the series coils are limited to a much less

space. In the same way, having found the maximum number of ampère windings, *i*, *d*, of the shunt coils, and having given its allowable current and the maximum potential at the armature for full load, the rest of the calculation is the same as that for ordinary shunt machines.

On account of the inflexibility of the thick wire, the series coils are generally wound first and the shunt coils over them. In that case care should be taken to correct the mean length of the shunt windings; for what was before the space occupied by the core for an ordinary shunt machine, is now that occupied by both the core and series winding. Another way to wind the magnets is to place the series coils at one end of each, or of alternate magnets. This is not advisable, as it requires more time and care to wind them, and they are likely to slip over one another unless held by a guard of some sort, which occupies valuable room in the coils.

The diagram also shows at a glance how the ampère windings are divided between the shunt and series coils. The line, *s*, *t*, fig. 6, gives the corrected relation between the armature current and the required ampère windings for constant potential at the poles of the machine. The space below the line, *s*, *d*, will show

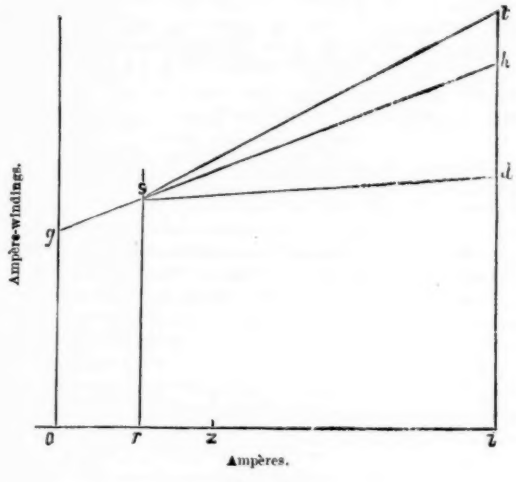


FIG. 6.

how much of the magnetism is supplied by the shunt coils, while the space between *s*, *d*, and *s*, *t*, shows how much is supplied by the series coils. The space, *s*, *r*, *o*, *g*, shows the proportion of the whole number of ampère windings required to generate the current for the shunt coils, and the space, *h*, *s*, *t*, that required to generate the potential lost in the series coils. If the current in the external circuit were *r*, *z*, for instance, it would be seen at a glance that the machine was running very uneconomically, as about half the energy generated is absorbed by the magnets.

For the "long shunt" winding, in which the shunt coils are connected with the poles of the machine, as shown in fig. 4 (ELECTRICAL REVIEW, May 28th), the corrections will be somewhat different. Referring to fig. 7, let *g*, *h*, represent, as before, the results of the experiment, as in fig. 5. In the same way as before, determine approximately the loss of potential allowed for the series coils and the total number of ampère windings which will be required to generate the proper potential plus what is lost in the series coils. Lay this off as *t*, *i*, then *t*, *g*, will give the corrected values for the ampère windings required. As the whole current passes through the series coils in this case, it is evident that their action will be proportional to the armature current and not to the external circuit current, as with the ordinary compound winding. From this it follows that the ampère windings for the shunt magnets must be that represented by *g*, *o*, and as this is constant for any number of lamps, *g*, *d*, is in this case horizontal, leaving *d*, *t*, as the number of ampère turns to be supplied by the series coils at maximum load. Knowing the whole current (including shunt) at this load, the number of windings is the quotient of the two; that is, $\frac{d\,t}{o\,i}$. Having thus found the number of windings of the series coils, and having given its maximum current and its allowable resistance, the rest of the calculation is the same as before. In the same way, having found the ampère windings of the shunt coils, and having given its allowable current and the constant potential at the poles of the machine, the rest of the calculation is the same as before.

The diagram also shows, as before, that the space below *g*, *d*, represents the ampère windings in the shunt; that between *g*, *d* and *g*, *t*, represents the ampère windings in the series coils. The space, *g*, *e*, *r*, *o*, represents the ampère windings required to supply the shunt current, and *h*, *g*, *t*, that required to supply the energy lost in the series coils. The distance, *s*, *e*, represents the ampère windings generated by the series coils on open circuit; that is, when they act together with the shunt coils as such. It will be seen, by direct comparison of figs. 6 and 7, in what manner the pro-

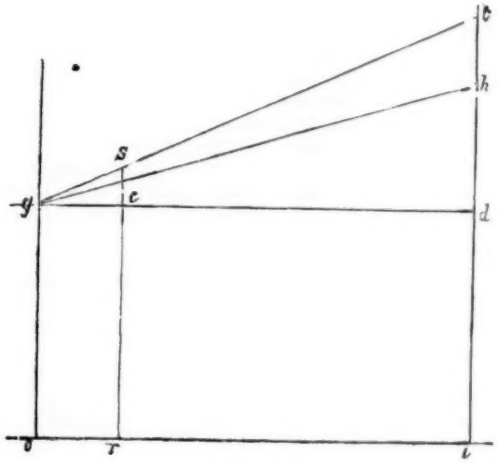


FIG. 7

portions of the different coils will vary in the two different systems. In fig. 7, the shunt coils are evidently smaller, and the series coils larger.

In many systems of distribution for incandescent lamps, the potential at the lamps will fall with an increased number of lamps, owing to the increased current in the leads. If it is desired to correct for this in the winding of the machine magnets, it is only necessary to increase the number of series windings by the proper amount, in order to generate the desired increase of potential at the poles, which can readily be calculated. This correction is made in the same way as that for the loss of potential in the series winding. If this correction for leads is comparatively great, care should be taken to correct the shunt winding also, on account of the increased potential at its ends.

As will be seen from the above description, much greater care must be taken, and more accurate calculations must be made for compound machines than for ordinary shunt or series machines. A change in one quantity will affect several others; especially is this the case with the speed, which should be kept the same throughout; if it cannot be maintained constant, there is little use in attempting to make the machine more than a rough approximation to one of constant potential.

If, upon running the finished machine, it is found to give too low a potential, owing either to an error in calculation or to the copper having a higher resistance than was assumed, a change in the speed will correct

the potential for that load; but the machine will then no longer have a constant potential, as a change in speed alters the required proportion between the series and shunt coils.

If it is desired to make final adjustments or to allow for slight errors in calculation, or for certain small changes of speed, the shunt coils may be so calculated as to have a somewhat smaller resistance than would otherwise be necessary, and then there may be included in its circuit an adjustable resistance; this will enable one to adjust the shunt coils. To adjust the series coils, they must be calculated for a somewhat smaller current than otherwise, and an adjustable resistance placed between the terminals of the series coils so as to shunt off a portion of the current. By this means both series and shunt coils can be adjusted or varied between certain limits, thus avoiding the necessity of great accuracy in calculation. This also allows for the correction of small unavoidable errors, and for adjustment for a slightly different speed. These adjustable resistances, after being set by experiment to their proper values, need no further alteration. From the different functions of the two coils it can readily be seen which of them requires to be varied in adjusting the machine.

In conclusion, let us examine the diagram, fig. 5 (ELECTRICAL REVIEW, June 4th) again, in order to see what are the best proportions for a good compound machine. As the curve of magnetisation, *a*, *c*, should be as straight as possible, the magnets should be of as soft a quality of iron as possible, and should just begin to be saturated with the maximum load. They should, therefore, be large enough, and there should be no great resistance to the lines of magnetic force by a scant allowance of iron at any part of their circuit. The magnets and iron should, of course, be arranged as economically as possible as regards utilisation of the field.

As the armature resistance increases, the angle which the line, *g*, *h*, makes with the horizontal increases, and hence, also, the number of series coils; in this case the deviation of the curved line, *g*, *h*, obtained from experiment and the straight line assumed, becomes greater, as also does the deviation of the finished machine from a constant potential one. From this it is seen that it is desirable to have the armature resistance as low as practicable, and, therefore, the field more intense, up to a certain limit. A Weston machine, exhibited at the Philadelphia Electrical Exhibition in 1884, had an armature of such low resistance that it had very nearly a constant potential without the use of any series winding. It is a question whether this is not the other extreme: that is, whether it would not have been more economical, as regards cost of material and construction, to make the machine somewhat smaller with a correspondingly higher armature resistance and a few series coils, at the same time letting the machine have the same efficiency and capacity: for, what is lost in the armature may be more than compensated for by the less intense field.

As the self-induction of the armature increases the sparking, it is well to have as few turns per coil on it as possible and a correspondingly large number of commutator strips or coils.

As the magnetic lag of the iron in the armature increases the difficulty of making the machine one of constant potential, this should be as small as possible, of the softest quality, and the number of windings on it as small as practicable.

As it is very desirable not to have to shift the brushes, everything possible should be done to avoid sparking and change of position of the line of commutation; or, what is the same thing, to avoid having to change the position of the brushes. Therefore, in addition to what has been said, the field should not be unbalanced, that is, the iron and coils should be so distributed that the field is symmetrical on both sides of the armature.

Lastly, great care should be taken in constructing compound machines, for if an error or fault shows itself, it cannot be corrected as readily as in other machines by merely changing the speed, coil resistance, or position of brushes, for these changes will change the compounding of the machine, so that it will then no longer have a constant potential.

Although it may hardly seem credible, yet the case has actually occurred in quite a large factory, that magnets were re-wound because the "direction" of the winding of the coils was not correct. It may, therefore, not be out of place here to remark that it is evidently quite immaterial in which direction the magnet coils are wound, as they can in all cases be connected correctly with each other and the poles of the machine. It is evident that there is only one right way and one wrong way, and if a certain connection is wrong it is evidently only necessary to reverse the connections of the two ends of that wire to make it right. The only advantage in winding a certain definite way is that the connections may then be as short as possible and have a better appearance.

It is always advisable in making the test for determining the proper ampère windings, to examine the pole pieces as regards their polarity, with a compass needle (being careful not to reverse the polarity of the needle in doing so), and to note it so that the coils of the finished machine may be connected so as to have the same polarity. Also find which is the positive and which the negative brush in the test, so that the compound connections may be made correctly before the machine runs, as much time can thereby be saved; for it is evident that with certain connections of the magnets with the brushes, the machine will give absolutely no current.

NOTE.—In discussing the subject of the saturation of magnets, in one of the earlier articles of this series, the constant 250 was given as representing, for a particular case, the number of ampère windings passing around a magnet for square inch of cross section of the core when just saturated. It was omitted to state, however, that this constant applies only to such forms of machine magnets as are in general use, and that for certain less frequently used forms it will be some multiple or fraction of this, as will be seen from the following:

Every wire conveying a current around a magnet is encircled by lines of magnetic force, of which those that pass through the armature are rendered useful. In following the course of these lines it will be noticed that most of those generated by one of the two magnets of, for instance, an Edison machine, must return through the core of the other magnet, or in other words, each coil tends to saturate both of the cores of the magnets. This may be more readily explained by the fact that the two magnets of an Edison machine are really the two parts of one and the same U magnet, or they may be considered as one bar magnet bent at its middle to bring the two poles nearer together. In the same way a Weston machine may be said to consist of two such U magnets with their two north poles terminating in one pole piece and the two south poles in the other. This is also the case with the Brush, Jenney, Crompton, Siemens, Schuckert, and many other machines with four magnet coils. The Thomson-Houston, Van Depoele, Hochhausen and like types may also be considered as magnetically equivalent to a pair of U magnets with the coils wound around the two pole pieces which the magnets have in common. The Mather type is quite different from these in this respect, as the entire U magnet is wound with wire. Another distinct type is found in the McTighe machine, in which the two U magnets contain each only one coil at what is frequently called the neutral part of the magnet. It might be compared to a Weston machine in which the two coils of each of the U magnets were placed together as one, on the end pieces or supports, or so-called neutral parts of the two magnets.

The saturation constant above referred to would therefore be quite different for some of the less frequently used types of magnets, unless it is taken as expressing the number of ampère windings on one whole magnet (from pole to pole) divided by the cross section

of the core of that magnet, or, in other words, if it expresses the allowable number of ampère windings on one whole magnet per square inch of core. If used in this sense it ought to be about the same for all types of magnets, and would evidently be about twice as great, or about 500 for a Weston type of machine.

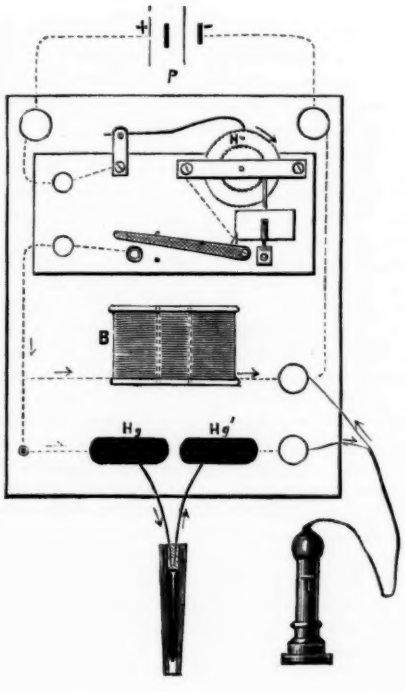
As iron becomes saturated when a certain amount of magnetism passes through every square inch cross section, a better saturation constant than the one used here would be the number of lines of force which may be passed through every square inch cross section of core at saturation. This would overcome the objection to using the number of ampère windings per square inch, as the latter is not the same for all sizes of coils, which is due to the fact that as the area increases the intensity of magnetisation diminishes for the same current.

The constant mentioned in the earlier part of this series of articles, may, however, be safely used, if, as described there, it is determined in each case. It will be found preferable to the other one just suggested, as it simplifies calculations.

It will readily be seen from what was said here about the different types of machines, that if the constant were 250 for the Weston type, it would, if other conditions were eliminated, be 250 in the Thomson-Houston type and 500 in the Mather and McTighe types.

APPARATUS FOR VERIFYING THE MANUFACTURE OF ELECTRIC FUSES.

IN the manufacture of electric fuses for igniting mines —remarks M. Ducretet in *Comptes Rendus*—it has been found needful to ascertain beforehand, by a rapid process, the quality of such fuses, so as to set aside all those which were not certain to act.



To arrive at this result, the fuses must be constructed in such a manner that the extra-current spark of the electric apparatus may strike with certainty in the midst of the composition of the fuse. We must, therefore, ascertain :—1. That the two copper wires are not in metallic contact, which would happen if the protective covering were removed. 2. That the two wires are still so near each other that the spark may strike between them.

These conditions, apparently very delicate, may still be verified in the most complete manner by means of an apparatus which I have constructed. This apparatus consists of a battery, P, of three Leclanché elements, the current of which traverses an interrupter, H, with a clockwork movement, then a bobbin of slender wire, B, and ends in two small cups of mercury, H g and H g'.

Lastly, a telephone, T, is placed on the circuit in derivation.

When the interrupter is set in motion, and one of the wires of the fuse is plunged into each of the small cups, there is observed in the telephone an unbearable noise, if there is metallic contact between the copper wires. If, on the contrary, the two wires are absolutely insulated, the telephone remains silent ; and, lastly, if the fuse is of good quality, we perceive a slight crackling, resulting from the passage of the electricity through the material of the fuse, which contains a large proportion of retort-carbon.

In the last case only, the fuse is recognised as of good quality, and we may feel assured that it will certainly ignite.

With this apparatus, therefore, we can in a very short time verify a large number of fuses, the resistance of which is higher than a million ohms, and be assured of their quality.

NEW ELECTRIC FUSES FOR THE IGNITION OF MINES.

THE ignition of mines charged with ordinary powder or dynamite — write MM. Scola and Ruggieri, in *Comptes Rendus*—presents numerous difficulties and dangers which might be entirely avoided by the use of our new electric fuses.

These fuses are composed of two copper wires, D, D, covered with cotton and coiled on a small wooden cylinder, C. Round these wires and their support is glued a paper cartridge filled with a priming composed of chlorate of potash, saltpetre, sulphuret of antimony, and retort-charcoal in fine powder ; the last-mentioned ingredient serves to give a slight conductivity to the mass.

The wires thus arranged are fixed at the extremity of a paper tube, A, A, which contains a port-fire or a powder-match, B.

If we wish to effect the explosion of a mine charged with common powder, we reserve in the mass a narrow empty cylindrical space, by means of a pin. The fuse described is placed at the upper part of this channel. It is merely necessary to connect the two wires to an induction coil, or, preferably, to the ingenious apparatus known as a "coup de poing," to obtain at the desired moment an extra-current spark which ignites the fuse-paste. The gases produced in this combustion ignite the match and project it with great velocity into the middle of the mine.

If we use dynamite we add a fulminating primer, upon which the match impinges at the instant of its projection.

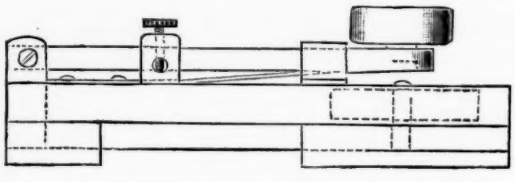
The use of our new fuses secures the ignition of mines, prevents any accident which might result from their hanging fire, and will, we hope, render excellent services in numerous branches of industry.

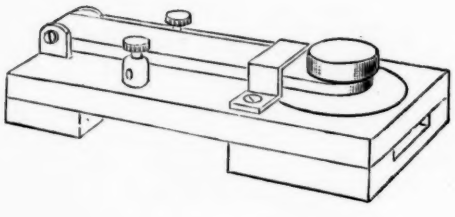
A MAGNETO GENERATOR KEY.

By SAMUEL VYLE.

GENERAL WEBBER'S valuable paper read before the Society of Telegraph Engineers, last year, on the working of the telegraphs in the Soudan, gave practical evidence of the good service rendered by the telephone when used as a receiving instrument; and so much was the Colonel Commandant of the Queen's Edinburgh Rifles convinced of its utility, that he wrote to a contemporary, stating his desire to equip his company therewith, but in an improved form. What he particularly wished to have was the ability to work the Morse code using the telephone as a receiver, *but to dispense altogether with batteries*, if possible. He further said he had enlisted to his aid high scientific authorities in the electrical world. It was by the persusal of that letter that the present writer was induced to attempt its solution.

After many trials to generate currents by some mechanical means, the author discovered that if a pair of Bell telephones be connected up as a closed circuit, and the ferrotype plate be removed from one of them, and the flat edge of this thin plate be tapped upon the magnetic core, within the wire coil, those taps generate currents which are distinctly reproduced in the second or receiving telephone. With a piece of soft iron of greater mass the signals are louder, but both dots and





dashes come out clear, and are as easily read as when a voltaic current is used. With a Gower-Bell magnet and its tiny coils, when tapped with a soft iron key, signals have been read through 30,000 ohms resistance.

Such an instrument was submitted in January last to the then Lord Advocate of Scotland, the Right Hon. J. H. A. Macdonald, M.P. (writer of the letter referred to), who expressed himself as much pleased with the results.

The accompanying key is its own generator, and is submitted for view and trial as admirably adapted for military purposes where the telephone is used as a receiver. Its construction is very simple, being composed of a small horseshoe-shaped permanent magnet; each pole being fitted with a soft iron core, wound with wire to about 50 ohms each, and joined up in series. The handle, or keying part proper is of soft iron, and when depressed against a spring, is brought into direct touch or contact with the magnetised cores in the centre of the coils, and at the same time the magnetic circuit is closed, thereby generating a vigorous current which is of longer, or shorter, duration, according to the time the two metals are in contact. A horseshoe magnet is not absolutely necessary, as when the core of a straight bar magnet is touched, the effect is the same to the ear, as if the magnetic circuit was completed. Touching with a magnet of opposite polarity to the core, gives results similar to soft iron; but if the core be in contact with a similarly magnetised pole, no current whatever results. It is clear, therefore, that mere hammering of the one metal upon another will not generate currents. The core is also dumb when touched with copper, brass, &c. Soft iron, nickel, and the opposed pole of a magnet, are the best touchers of a magnet. Of course much depends upon the size and capacity, as also upon the quantity, size of wire, and the method of joining up the coils. Anything intervening between the soft iron and the magnetised core of the coils, which prevents direct contact between these two, detracts largely from results. On the other hand, by winding the legs of a penny magnet with a quarter of an ounce of No. 40 wire, and tapping the poles with its tiny armature, currents are sent, and signals are quite readable through 5,000 ohms resistance.

From what has been said it is obvious that there are many ways in which this "touch of core" method of generating currents can be utilised; but conspicuous above all is its fitness for military telegraphy, in conjunction with the telephone as a receiver, as batteries are thus dispensed with.

[We may remark that an instrument on a somewhat similar principle to that of Mr. Vyle's will be found described in the No. of the REVIEW for August 19th, 1882. The "touch of core" principle was many years ago made use of by the late Sir Charles Wheatstone, (see TELEGRAPHIC JOURNAL, No. 1, Vol. I.). The principle was also applied by the late M. Breguet to magneto exploders.—EDS. ELEC. REV.]

ELECTRICITY IN THE ROYAL NAVY.

[FROM A CORRESPONDENT.]

THE 150 members of Parliament who, with Captain Lord Charles Beresford as their *cicerone*, visited Portsmouth on Saturday, had an opportunity of witnessing some interesting submarine and electrical experiments, which, though not at the present time of a particularly novel description, serve to mark the rapid progress which has been made in electrical science as applied to naval warfare since the last visit of representatives of the Lower House, now some eight or nine years ago. The morning having been devoted to a sham fight at Whale Island, the M.P.'s proceeded, after lunch, in dockyard tugs to Porchester Creek, where, under the superintendence of Captain A. J. Fisher, of Her Majesty's gunnery ship *Excellent*, assisted by Commander Macleod of the same vessel, an interesting programme was carried out to the manifest amazement of some of the visitors, whose Arcadian simplicity with regard to naval matters afforded no end of amusement to those whose education has been more complete in the matter. The old-fashioned outrigger torpedo boats, in which electrical apparatus was made use of, although not to the same extent as in the newer type of craft, afforded a striking proof of what has been accomplished in a comparately short time. These boats were very carefully manœuvred, and the *modus operandi* of their attack succintly explained. Another operation was destroying electric cables and "bumping" submarine mines. This is one of the latest developments of naval warfare, and was effected by means of a bulky and far-reaching apparatus being dragged over the torpedo grounds by a steam launch, which keeps at the distance of about 500 yards away. On the first mine exploding, the electric cables connecting the others were so affected that they also were destroyed. After this, attention was directed to a second class torpedo boat coming from the head of the harbour in the direction of the tugs in which the "members" were accommodated at a furious speed. Without

slackening, a torpedo was shot out at right angles and struck the target. A first class torpedo boat afterwards fired two of her deadly charges simultaneously, and both were very near the target. The improvements which have been made of late in the mode of discharging torpedoes by means of electrical apparatus has greatly conduced to a greater degree of precision in aim being attained, and with still further developments in this direction there can be little doubt that almost perfect exactitude will ultimately be reached. Perhaps what astonished the Legislative body most was the explosion of mines. The latter were 2,000 yards apart, and connected by an electric cable. At one end one of the mines was "bumped," and by means of the ingenious electrical apparatus which was made use of on the occasion one at the other end exploded almost simultaneously, sending up a huge volume of water, resembling a waterspout of large dimensions. This experiment was intended to illustrate the manner in which sunken mines, covering large areas, may be exploded from the shore when used for the defence of harbours, rivers, &c. Other experiments of a minor nature were also made, and afterwards the party proceeded to the turret ship *Colossus* at Spithead, and inspected the various minutiæ of that large vessel, which is fitted with all the latest developments which naval science can supply. Electricity is used to a very great extent on board this Leviathan of the deep. It is of course fitted in every part with the electric light, has search lights of the most powerful and penetrating description, its turret is worked by electricity, and its guns fired by the same power. After this the members returned on shore, and left by train for London, after a holiday which the amenities of party politics must have transformed into something delightful indeed.

ELECTRIC LIGHTING AT THE LIVERPOOL EXHIBITION.

IN an article upon the Exhibition at Liverpool, the *Times* makes the following remarks upon the electric lighting systems employed:—"Electric lighting forms so important a feature of the Exhibition that some notice of the different systems employed may be useful. Both arc lamps and incandescent lamps are used—the former of 2,000 and 3,000 candle-power, the latter of 10 and 20 candle-power. As these lamps, with relative dynamos, are furnished by five different firms, an excellent opportunity is afforded of comparing, not only the effect of the two kinds of lamp, but also the systems of different patentees. The five firms supplying the lights are Richard Miller, Glasgow, who provides the Thomson-Houston arc lamps; Andrews and Co., Glasgow, the Anglo-American Brush Company, London, Gülcher & Co., London, and King, Brown and Co., Edinburgh. The largest share of the lighting has fallen to the Thomson-Houston system of arc lamps. It is used in the outside lighting of the grounds at the west front of the building, in the grand hall, in the picture galleries, and the eight north-western courts—155 lamps in all. The Andrews arc lamps are used, to the number of 30, in the south-eastern courts, including those filled with machinery in motion. The Anglo-American Brush Company furnishes 55 arc lamps for the north-eastern courts, and 250 incandescent lamps for Old Edinburgh. The south-western courts are lighted with 32 Gülcher arc lamps, and the same company lights the grounds north and east of the building with the same number of lamps elevated on tall masts—four on each. King, Brown & Co. light the central court, which is 750 feet long, with 1,425 incandescent lamps, and the north promenade outside the building with 1,200 incandescent lamps in coloured globes, hung in festoons from three rows of Venetian masts.

"King, Brown & Co.'s dynamos are worked by six Marshall engines, one with two dynamos being a reserve. All the other dynamos are worked in a single court by six engines—four by Robey, one by Adamson, and one by Marshall. The steam power for all these engines is supplied by six large boilers placed in a recess between the 16th and 18th courts on the south side of the building.

"There can be no doubt that, both for brilliancy and steadiness, the palm must be given to the Thomson-Houston lamps. The grand hall and the picture galleries are as brightly and as pleasantly lighted by night as they are by the noon-day sun. Between the other systems of arc lamps I cannot venture to discriminate. They are all good, though none of them can be compared with the Thomson-Houston system. The lighting of the central court with incandescent lamps is not quite satisfactory. The intensity of the light varies, and even at its best it cannot compare in brilliancy with the arc system. It ought to be said, however, that the comparison is not quite a fair one. The equivalent of 1,425 incandescent lamps of 20 candle power, is only 9½ arc lamps of 3,000 candle-power; but if the central court were lighted with arc lamps in the same ratio as the side courts are lighted, not 9½ but 44 arc lamps would be employed. In this view, it may be maintained that the incandescent system is the more economical, and that its comparative failure is due to the fact that too few lamps have been employed. Certainly the vista afforded by the central court when lighted up is very fine as a pyrotechnic display. Much the same may be said of the illumination of the north promenade. The combination of colours is very effective; but the lamps do not light up the promenade. The lighting of the shops and houses of Old Edinburgh with the incandescent lamps of the Brush Company is much more successful than that of the central court, but the limited areas that require illumination may tend to produce a more favourable result. Altogether, the electric lighting of the Exhibition is a notable success."

INCANDESCENT LAMP PATENTS.

EDISON *v.* WOODHOUSE AND RAWSON
AND
EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY *v.* WOODHOUSE AND RAWSON.

(*Before* MR. JUSTICE BUTT, *sitting for* MR. JUSTICE NORTH.

(*Continued from page* 521.)

Wednesday, May 12th, 1886—(*continued*).

MR. JOHN IMRAY, cross-examined by the Solicitor-General: I ask you to turn again to M. Sidot's paper. Those who instruct me were rather surprised at one or two answers which you gave. "Differing also from this last in regard to conductibility for heat and electricity." In that passage he has compared carbons which he produced in the mode he described with other carbons, in respect of conductibility and in respect of elasticity?—No. In respect of the conductibility of heat under electricity, and also in respect of elasticity.

He is comparing the carbons which he has produced in the method he has described with other carbons in point of conductibility, and in point of both heat and elasticity?—Yes.

I am quite aware that you want for a conductor in an incandescent lamp a material of high specific resistance, and you will probably tell me that carbon is a suitable material for this purpose; but amongst carbons it is good to have a good conducting carbon, is it not?—Well, a uniform conducting carbon.

But a good conducting power—otherwise it will not carry the current—will do?—What you want is resistance.

But you do want your current carried through, do you not?—Yes.

I will refer to this passage, which I think you have misunderstood: "Pencils made from this give a much more intense electric light than those which are obtained from gas retort carbon." He is there speaking of electric light giving pencils?—The arc light.

You keep on repeating the words "arc light." If you had waited till my next question you would have seen it was not necessary to have been so anxious to repeat them. Is there anything in that language, "pencils made from this give a much more intense electric light," which in itself, according to the literal meaning of the words, is more applicable to the arc light than to the incandescent light?—Yes. There are a few words which show this distinctly, because he compares them with the carbons made from gas charcoal, and all the carbons made at that time were made from gas charcoal.

And also for incandescent lamps?—There were no incandescent lamps made at that time.

Did not King, in the year 1845, describe an incandescent lamp with a carbon conductor made from gas retort carbon?—Yes; and many other people have described it, but it never was commercially used.

I am not asking you that. "This carbon conductor becomes heated in the same manner as a metal, and becomes gradually incandescent over its whole surface." Now, you told Mr. Moulton that the conductor did not become gradually incandescent, but that it became incandescent all at once?—Yes; throughout its whole mass.

I speak with some diffidence; but that is not scientifically or theoretically true, is it? You cannot measure the distance of time which the electric spark takes to pass from one part to the other?—It is so rapid that one cannot measure it.

But still, theoretically it does pass through, and it is only that it passes so rapidly that you cannot measure it?—I suppose so.

Let me ask you whether the meaning of it is not this, that the heat first causes a dull red light and then becomes more incandescent?—No, that is more inconsistent with the language.

I am asking you whether it is not a fact that when you light a carbon conductor it first glows with a dull red light and then progresses gradually into incandescence?—Yes.

Must not this language be referring to it becoming gradually incandescent over its whole surface? That is to say, from what I venture to call a dull red light into a bright incandescence?—No; because it contrasts the doing of it throughout its whole mass with doing it at one point.

Let me read the whole sentence to you. "And becomes gradually incandescent over its whole surface without becoming bright at any particular point." Does not that mean this, that it becomes gradually incandescent over its whole mass, instead of becoming irregularly incandescent, brighter at one point than at another?—No, I think not.

Is not this [pointing to the lamps in the court, just now lighted] progressively incandescent?—Progressively in point of time, but not in point of length.

Mr. MOULTON: Those are the ordinary carbons, not Sidot's.

Mr. JUSTICE BUTT: That is rather a striking passage about it getting cold when withdrawn from the fire.

The SOLICITOR-GENERAL: The way it is translated is that it becomes cool immediately you remove the heat, and the French is "*aussitot qu'on retire du feu.*"

Mr. JUSTICE BUTT: I understand the witness to say that that is the view he takes about it, that he is not talking about electricity at all, but fire.

The SOLICITOR-GENERAL: I will not take up your lordship's time by arguing that with Mr. Imray.

Mr. ASTON: I think the language would show that it is retiring it from the fire.

The SOLICITOR-GENERAL: It is no doubt "retire it from the fire," whatever that may mean. I am sure your lordship will appreciate the witness's suggestion that that indicates to him that the heat spoken of was not by the electric current, but ordinary heat. [To witness] I will refer you to page 2 of Scott's specification of March 2nd, 1878, No. 249: "My invention consists secondly in manufacturing flexible bands, ribbons, or cords of carbon, or mixture consisting essentially of carbon, to be used as hereinafter described in the production of light by electricity. I take the carbon or carbon mixture and incorporate therewith fibres of asbestos or fibres of hemp or other mineral or organic fibres, together with adhesive matter as hereinbefore explained. By rolling or otherwise I form the mixture into long bands, strips or ribbons and dry them with heat." Could you not employ these flexible ribbons, strips or cords of carbon or mixture consisting essentially of carbon, as carbon conductors in an incandescent lamp?—I think when you are shown the way you could.

Is there anything to show you? Could you not cut off a piece of Scott's ribbon and put it between two platinum wires and enclose it in a vacuum?—It would make a very large incandescent lamp.

Very likely. But suppose you made one of his cords or wires very small?—Yes. He does not carbonise afterwards.

He carbonises first?—He makes the carbons first, but he does not carbonise after he has given them the form.

That is quite true; but does he not suggest to you a mode of manufacturing carbon ribbons, strips or cords which are capable of being used as carbon conductors in an incandescent lamp?—I do not think they would do unless you carbonised them afterwards.

Do you suggest that for a carbon conductor, so far as conductibility is concerned, it makes any difference at what period the carbonisation takes place?—Yes; it makes quite a different thing to the constitution of the cord.

Supposing you had a carbon strip of any kind and put it into a vacuum with the platinum wires, would not that be a carbon filament?—That would be a carbon filament.

You said Edison and others had used lamps with metallic wires, and that he now proposed to substitute carbon wire, the advantage of which was that it could be bent and turned upon itself into a loop, and by using a filament sufficiently flexible for that purpose before carbonising and sufficiently stiff after carbonisation to retain the form?—Yes.

Will you point out to me any passage in Mr. Edison's specification in which he points out those requirements, except with regard to the spiral. I am quite aware of the passage with regard to the spiral, and I do not want to have that put upon me?—Well, that is turning it upon itself.

It is then only with regard to the spiral that he points out the desirability of its being flexible before the carbonisation and stiff afterwards. Is that so?—Yes; it must be flexible. He describes flexible materials to be used.

For making the spiral?—Yes; or even without the spiral.

I should like to know where that is. On page 4, line 39, he says that he has carbonised and used linen thread, wood splints and paper coiled in various ways. Then he points out to you there what you told us you found in this patent, that it must be a substance sufficiently flexible to receive its shape before carbonisation, and after carbonisation sufficiently stiff to retain it?—Yes, because he describes certain things that have that, and he has shown in his drawings the form that he describes.

But in the drawings he speaks of nothing but the spiral?—Only the spiral.

Then it is only from his mentioning cotton thread or any fibrous vegetable substance which will leave a carbon residue after heating in a close chamber, that you infer that?—Yes; he wanted to substitute a carbon filament for a metallic wire, and it ought to have the same qualities in that respect as the wire that has to be bent to the shape first and carbonised to retain that shape afterwards.

But he has not told the world, except so far as it is implied in the words, "A fibrous vegetable substance," that it was to have those qualities?—Yes; he tells you he makes an artificial carbon. It is a carbon wire, and he tells you that he uses other things, such as cotton and linen thread, and wooden splints, all of which have those particular properties.

But he does not tell us, except in your inference from the materials which he suggests, that the essential thing is to have a carbon filament which will be flexible before carbonisation, and rigid afterwards?—Not in so many words.

In this passage which you refer to he is only speaking of a fibrous vegetable substance in connection with its being coiled?—Yes.

And the passage to which Sir Richard Webster referred in his opening, "the spiral after carbonisation retains its form," only applies to the spiral?—Yes; but, of course, it would apply *a fortiori* to other forms.

Is there anything whatever with regard to the spiral in which Edison has either pointed out a preferable shape, or, still more, confined himself to any shape?—No, there is not.

So that a straight conductor would be equally within his patent as any other shape?—I do not think it would; it would not answer the purpose he has in view.

That is your opinion as a scientific man; but I am asking you, as an experienced person in patents, whether Edison's patent claims any preferential shape, or any shape at all?—No, it does not claim a preferential shape.

Nor is there a single suggestion that you should shape your fibre before carbonisation, except with regard to the spiral?—No.

I think I might go a little further and say that in Edison's later patent he does describe a mode of making a carbon filament stamped out of Bristol board?—I believe so.

But in the patent sued upon he does not give you any mode either of making it or carbonising it, except with regard to the spiral?—No.

He does not give you, for instance, any model or block, or any process by which you are to get a particular shape, or indicate to you how you are to get a particular shape, except with regard to the spiral?—No, he does not.

Or at what stage its shape is to be given to it?—No; but he said before carbonisation, certainly.

That is a fallacy which Sir Richard Webster has suggested. There is not a word in the patent about it. He says on page 4, line 42: "If the carbon thread is liable to be disturbed during carbonisation," and so on.—He shows distinctly how it is to be coiled before carbonisation.

Is he not there speaking of the spiral?—Yes.

I ask you, excepting with regard to the spiral, is there any indication with regard to the carbon filament *simpliciter* as to the stage at which it is to receive its shape?—No, of course not?

Now, as you referred to the figures just now, I will ask you whether reference to the figures and the detailed description of burner does not relate only to the spiral?—It shows only the spiral.

Perhaps it is an unfair suggestion on my part, but do you think that the filament of carbon of high resistance, made as described in the first claim, means the detailed description which is given in the letterpress and in the figures?—Yes.

Exclusively?—Substantially.

You understand what I mean: that is, the spiral only?—Oh, no, no; the spiral he says is a preferential form, and then he makes a special claim for it, but he does not confine himself to that at all. He says, I prefer the spiral form for reasons which I give, but I should have a filament, whether spiral or not.

You suggested that one of the great advantages of this was that you could have both wires at one end of the receiver, instead of passing out at separate ends?—Yes.

I have no doubt you are quite right; but there is nothing about that in the patent?—No; but he shows it in his drawings.

There is nothing which would enable him to claim that as one of the advantages which he has pointed out to the public?—I think he has pointed it out clearly in his drawings.

But there is nothing in the letterpress, is there?—Not in the letterpress, in any words which I can see, except the description of the drawing.

But the drawing, you told me just now, is only a drawing of the spiral?—That shows the spiral only.

Re-examined by Mr. ASTON: You are asked whether in Edison's specification he describes any mode of manufacturing a filament otherwise than in connection with the spiral. In your opinion would the description which he gives of the manufacture of a filament with the view of its being formed into a spiral be sufficient to make a filament such as is in any of the lamps now before his lordship?—Yes; it is only a spiral with one or two fewer turns. It is only a question of the number of turns.

As regards the preparation of the filament and its character when made, is there any difference between this filament with one curve and that with two or more curves?—No; it is the number of convolutions.

The SOLICITOR-GENERAL: Sir Richard Webster opened his case by saying that they did not charge infringement with regard to the spiral.

Mr. ASTON: I do not say that. If I understand the Solicitor-General's questions, which were very close, they were to the effect: "Is it not a fact that the description here given of the preparation of the filament is a description which only applies to the spiral?" and the witness said "Yes." I think it is fair for me to ask, Is the description given as to the spiral sufficient for the preparation of the filament in any other form required for an incandescent lamp?—Certainly; you may have one turn or 20 turns of the spiral.

As regards the directions given by the specification, are they sufficient for the preparation of both forms?—Yes.

As far as I understand your answer to the Solicitor-General, you said that in your opinion the filaments referred to in the first claiming clause need not be spiral filaments?—No, I think they need not.

Would the conditions for an electric lamp be answered whether the filament had one turn, two turns, or more?—Yes.

Were you in court when Sir Fredk. Bramwell was asked as to the meaning which he attached to the specification No. 5,127 of Edison for 1879?—Yes, I heard it, I think.

Do you agree with Sir Fredk. Bramwell as to its being a further improvement founded upon the substratum of 4,756?—It describes a particular carbon made of paper.

You were asked whether there was any description of the mode of carbonisation save and except as to the spiral. As to the spiral there is a description, is there not, as to the mode of carbonisation?—Yes; not a detailed description, but still a sufficient one. It tells you that you are to put it into a closed vessel and subject it to heat, and thereby reduce it to carbon.

Would those directions be sufficient for the horseshoe shape or any other shape?—For any shape. It is a well-known process of carbonisation; it was known long before this.

What in your view would be the meaning attached by a person acquainted with the subject matter to the directions that are there given as regards the character of the filament that would be produced?—What I say is, they must make it flexible to begin with, and carbonise it; put it into its shape and then carbonise it.

Whether the words are omitted or not, do I understand you to say that the directions given would of necessity relate to any other flexible and elastic carbon filament?—Yes; because he mentions nothing but what is flexible.

The Solicitor-General read to you that passage in Scott's specification from "My invention" down to "dried them with heat," and asked you whether, in your opinion, that filament was suitable for, or could be used in an incandescent lamp. Having regard to the fact that it goes on to say that when the fibre is mineral the heat applied may be sufficiently high to decompose the flour or starch base, but when organic fibres are employed the heat employed must not be so high as to decompose those fibres; going on, and bearing that in mind, do you now say that the filaments would be suitable for an incandescent lamp?—No; I said he did not intend to carbonise, therefore it would not be suitable.

Turning to Edison's 2,402, of 1879, the Solicitor-General asked you whether the carbon sticks that are referred to may not be carbon sticks capable of being used in incandescent lamps. I ask you to read that: "Carbon sticks may be also freed from air in this manner, and be brought to a temperature at which the carbon becomes pasty, and if allowed to cool is very homogeneous and hard. Rods or plates made of mixtures of finely divided conducting or non-conducting materials may thus be freed from air." Now, having regard to the fact that in juxtaposition carbon sticks, rods, and plates are referred to, what do you say is the inference a practical man would draw from the words and statements therein made?—I should say for arc lamps, because all these things had been used in arc lamps at this time.

Now, although carbon sticks may have been used in incandescent lamps, sticks of carbon would not be a form of carbon likely to be used, because you are told in all cases to make them as thin as you can, are you not?—Yes; I do not think it would be very likely to be used.

Are the directions which are given for the preparation of carbon conductors, as a rule, to thin them down?—Yes.

What were the means employed up to this date to produce a thin carbon rod or pencil?—Sawing or filing down.

In what state was the mass of carbon usually from which those rods or pencils were prepared?—As hard and homogeneous as possible.

And as regards form?—Well, very much larger than the finished form.

As they were clipped off from the retort, I suppose?—A very crude form.

It is a kind which one finds commonly in gas retorts when gas is made?—Yes. Great masses adhering to the sides of the retort and having to be chopped off with chisels. They come out in a crude form like great lumps of coal, and are then cut into shape.

Mr. ASTON: I should like to ask your lordship's permission to try one of Gimingham's lamps in court, if your lordship will allow that to be done to-morrow. The lamp will be prepared with Gimingham's terminals, and your lordship will see the effect of it.

The SOLICITOR-GENERAL: Of course your lordship will do anything, and I will consent to your lordship's doing anything, which you think will be of assistance to the court, but I am bound to say I do not think an experiment of that kind would be in the least degree useful, and it only shows a misapprehension of what I have been endeavouring to get the witnesses to prove, that after the heat has been applied for any length of time the joints become loose and useless. Trying it for ten minutes or a quarter of an hour will not be the slightest answer to my suggestion. But I do not oppose any experiment your lordship thinks desirable.

Mr. JUSTICE BUTT: I am rather opposed to experiments of that kind, because they are endless, if you once begin with them. If you wish to suggest it further on you may do so. There seems to be that objection, that it may answer perfectly well for an hour or so, but unless I can sit here for a week and look at it, I do not think I should derive much benefit from it.

The SOLICITOR-GENERAL: And this would be a specially made one.

Mr. ASTON: Another question I should like to ask the Solicitor-General is with reference to the proving that the combination was made by Edison in the regular way, and that he filed his declaration in the regular way, and that the complete specification is filed. I do not know whether my friend will put me to the necessity of calling Mr. Brewer.

The SOLICITOR-GENERAL: Oh, no.

Mr. ASTON: I am putting this question because I do not propose to add to the scientific evidence already given, except to ask Prof. Dewar a few questions about the construction my learned friend is putting upon Sidot, which rather takes our scientific witnesses by surprise.

(The Court then adjourned for the day.)

Thursday, May 13th, 1886.

Professor JAMES DEWAR, F.R.S., Professor of Natural Experimental Philosophy at Cambridge, and Professor of Chemistry at the Royal Institution, examined by Mr. Aston, said he had since 1872 made a series of special investigations on the properties, physical and chemical, of carbon at high temperatures. About 1879–80 he made a series of practical experiments with reference to the effect of heat upon carbon. He read Sidot's papers in 1879, having at that time great difficulty in discovering any method of getting over the natural inequalities of carbon—the chinks and holes, and porosities. His object was to use carbon in the form of tubes, and these tubes he wanted to resist a certain small amount of gaseous pressure; for that purpose he tried all varieties of carbon, ordinary gas retort carbon, carbon produced by hydraulic pressure, and various means, and special carbons were made for him by the late Sir William Siemens, but all showed the porosities; therefore he read up the literature as far as possible, and tried to devise some means of filling up the pores. When he saw M. Sidot's paper on the advantages of disulphide of carbon he naturally tried the method which Sidot described, and he now produced some tubes which he used in the original application. He did not know at that time of any means of obtaining carbons taken from a gas retort in the form of a long cylinder of very small section, having flexibility and elasticity; but during his experiments he formed what Sidot described at the end of his paper. Sidot's paper was on the action of disulphide of carbon and carburetted hydrogen on wood charcoal. Witness placed his imperfect tubes, some of which were made of compressed carbon, and some of drilled gas retort carbon, in the interior of a porcelain tube as described, heated up to a white heat, and passed over these various kinds of carbon, the vapour of disulphide of carbon, or of some hydro-carbon. The surface of the interior of the tube became coated with an irregular deposit of a dense variety of carbon, as Sidot described it.

Mr. ASTON: Did you at that time treat anything of so small a section as to have a filamentous character?—No, not at that time. I ought to say, however, that the description which he gives in the last sentence, in which he refers to the growth of something like a filament on the walls of the tube, was perfectly familiar to me, and it is an actual fact. Here is a specimen of a porcelain tube which shows this particular growth which he calls filamentous.

Is there anything there of a globular character?—Yes; when you look at it with a lens you can see that these so-called filaments are evidently the growth of a succession, I take it, of small bituminous bubbles. Sidot calls them *"petites boules juxtaposées."*

Can you show my lord a deposit which answers to the character given to them by M. Sidot when he says *"les filaments paraissent etre formes par des petites boules juxtaposées?"*—Here is a section of an actual porcelain tube which I used yesterday, in which you will see this growth. If it is looked at with a lens, you can see the so-called filaments have this character, but it is much more apparent where the operation of M. Sidot has been applied to a carbonised filament.

Mr. JUSTICE BUTT: I suppose there is a want of continuity

throughout?—Yes; there is continuity, but you will see it very slightly in this specimen.

Mr. ASTON: Before I put the question whether Sidot's process would answer for preparing a carbon filament for an incandescent lamp, let me ask you to tell my lord what further experiments you have made in order thoroughly to enable you to answer that question.—I took a quantity of common linen thread and carbonised it. I placed it in a porcelain tube in the middle of a furnace, and I passed over it the vapour of a hydro-carbon. The result is the growth of these irregular filaments, the deposition of this conductive carbon on one portion of the carbon filaments.

The deposits were irregular?—Quite irregular, one portion only of the original fibre being coated with the new deposit.

Now, I put the question to you whether Sidot's process, having regard to the results you have obtained, both in 1879 and yesterday, enables carbon filaments to be made such as are described by Edison in his patent?—Certainly not, because they are irregular and brittle.

Would they be suitable for being used in an incandescent lamp?—Absolutely useless, I should think.

Mr. JUSTICE BUTT: I am expressing no opinion whether it does or not, but if Sidot's results would be of no assistance whatever in the forming of an incandescent lamp, then Sidot does you no harm. I shall hear the cross-examination, but so far as it has gone I gather Prof. Dewar's evidence to go directly to that.

Mr. ASTON (To witness): Now, there are references to conductivity in this paper?—Yes.

What kind of conductivity do you say Sidot was referring to and investigated?—In one part he says that this particular conductive carbon is distinguished from ordinary carbon by its greater conductivity both for heat and electricity.

Did you make any experiments for heating carbon by passing an electric current through it?—I was in the habit of doing so daily.

But with reference to this particular experiment?—No, I regret to say it never struck me to use electric heating in the presence of an atmosphere of hydro-carbon.

Why do you say you regret to say that?—Because if I had known that I could have got the deposit just where it was wanted for my purpose. I was not looking for incandescent lamps; I wanted to get a very small tube made fairly tight.

And the deposit uniform?—For my purpose, if I filled up the irregularities, that would do.

Mr. JUSTICE BUTT: Does Sidot heat by electric current?—No; he says he introduces pieces of wood charcoal, and then passes the vapour first at a low temperature, and then heats gradually.

Mr. ASTON: When comparing wood charcoal with prepared charcoal, as regards conductivity, do you think that conductivity had any reference to the passage of an electric current?—Not in the passage that was referred to yesterday.

Why not?—Because it is quite incompatible with the other parts of the sentence.

Would wood charcoal have any conductivity of any appreciable character?—Wood charcoal has no conducting power of that kind that anyone could apply for incandescent illumination.

Having had your attention called to all these circumstances, is there, in your opinion, anything in Sidot that would lead any person to treat a carbon filament by passing an electric current through it and heating it in a carbon atmosphere?—No.

Cross-examined by Mr. CHARLES: Does your answer as to incompatibility apply to the last paragraph of the extract?—It does.

And to the paragraph commencing: "The same carbons?"—Yes.

"The same carbons, which are distinguished so completely by their elasticity from ordinary carbons, differ also from these last in their great conductibility for heat and electricity. Pencils made from this give a much more intense electric light than that which we obtain from gas retort carbon. This carbon conductor becomes heated in the same manner as a metal, and becomes gradually incandescent." That is "this carbon conductor" of electricity, is it not?—No; that is not my translation. Of course, I do not pretend to be a thoroughly linguistic French scholar, but I translate it in the way which was right to my mind, and is right now. It means "this conductive form of carbon."

Mr. JUSTICE BUTT: It is quite clear that the word *conducteur* is the adjective; it is carbon which conducts. That is my translation of it.

Mr. CHARLES: I don't care which way I take the translation. The conductivity of that carbon had been described in the previous paragraph, had it not, as a conductor of heat and electricity?—No; he says in the previous paragraph that it has both those qualities, and he refers then specifically to its conductivity for electricity when he says he believes he could replace the carbons in the Bünsen piles.

Why, when you read those two sentences together, should you cut down the meaning of the words "this conductive carbon" to mean "this carbon conductive of heat?"—Simply because the rest of the sentence tells the chemist what he means. He says this conductive carbon becomes hot in the same way that a metal does, and he says it becomes progressively incandescent in the whole of its mass, and he contrasts that property now with the ordinary carbon, which he says has not that property. Now, if an ordinary carbon has not that property it is quite clear that he is contrasting some other property of carbon, because the ordinary carbon has not electric conductivity, so it cannot refer to that.

Mr. JUSTICE BUTT: And he says it cools immediately he withdraws it from the fire.—That refers to the well-known property that wood charcoal inserted in a fire and withdrawn from the fire will not cool in a body, but cools irregularly, with combustion at various points. I will show you what I mean. This is a piece of Siemens carbon, and there is a piece of ordinary wood carbon, which has been inserted for a few seconds and taken out. You see that combustion takes place at points of this from the formation of the ash, whereas this piece of Siemens carbon has no ash on it at all. It heats up uniformly, and it cools down uniformly. That is all he means. It is a simple elementary chemical fact.

Mr. CHARLES: I understood you to say just now that wood charcoal was not a good conductor of heat?—Not for practical use for the purpose of an incandescent light.

Is not bamboo thread carbonised wood charcoal?—Yes.

Is not that a material Edison uses in his lamp?—That is quite true, but the wood charcoal he is referring to is clearly a variety of ordinary wood charcoal which is well known not to have that property, and otherwise he would not contrast it with that.

Does not the conductibility of wood charcoal vary a great deal with the wood you use, whether it is close or not?—It does, with the density of the carbon.

If you get a dense wood, wood charcoal may be a conductor of electricity?—It might, but he says here ordinary wood charcoal, and therefore he does not mean any specifically dense wood charcoal produced from *lignum vitæ*, or anything of that kind. He uses the words "ordinary carbon." Any other carbon would be more expensive.

He gives several instances of the woods which he would use?—Which he did use.

"The substances of the most different woods, such as box, ash, elm, lilac, alder, and cork can make this new carbon."—Yes.

You did not in your experiments, I think I understood you to say, use wood carbon?—I did not. I had no object in doing so. It would have been useless for my purpose.

There is no doubt, is there, putting aside for a moment whether it is suitable for an incandescent lamp or not, that this process of Sidot's is a process by which a carbon filament was made?—Yes; of a kind which I have described.

Mr. JUSTICE BUTT: Apart from what M. Sidot has said should you call it a filament?—No.

Mr. ASTON: "*Petites boules juxtaposées.*"

Mr. CHARLES: I am talking of the process described in the earlier part of the paper. What would you call his carbonised thread? Sidot says he has reached the same results with thread, hemp, cotton, paper, and silk. Why would you not call the carbonised thread a carbon filament?—I would simply say that the difference is this, that if it was a filament when it was inserted it certainly is not a filament when it comes out of such a process.

It may be a carbonised filament?—An irregularly carbonised filament.

Mr. JUSTICE BUTT: Do you not agree that when he speaks of "these filaments" he refers to all filaments which he produced, whether from thread, silk, or cotton.

Mr. CHARLES: No, I think not.

Mr. JUSTICE BUTT: Then I have misunderstood it. I understood it so, and I understood it to mean that all the filaments he produced were composed of what he calls "*petites boules juxtaposées.*"

Mr. CHARLES: I think not, my lord. I think he says: "This carbon in fact presents itself in the form of filaments of one centimetre in length constituting a kind of silky and frothy coke white like silver. These filaments appear to be formed of little balls touching one another."

I answer your lordship by saying that the words "these filaments" there meant the filaments lastly mentioned by Sidot. I am going to ask Professor Dewar this: Does he not indicate a mode of preparing a carbonised thread? I will come to the irregularity afterwards.—I presume that he means that he did use there these various substances in a carbonised form.

What distinction do you draw between a carbonised thread and a carbonised filament? What is a filament but a thread?—I think a filament means a very fine thread.

That is the only distinction you can make?—That is the real distinction.

Does not the simple word "thread" convey to your mind the idea of fineness?—Not in the same way that filament does. That is not the way that the word filament is ordinarily employed. In physiology nervous filament refers to something very much thinner than thread.

You do not agree with Mr. Edison's view when he uses indifferently the words "filament or thread?"—I say that "filament," to my mind, conveys the idea of a fine thread.

But the degree of fineness you cannot tell us?—No.

At all events you would say the only distinction between the two words, if there is a distinction, is in the degree of fineness of the material?—I think so.

Mr. JUSTICE BUTT: This is all very fine, but what I want to get at is this: When M. Sidot speaks of treating linen, cotton, silk, and so on, by his process does he get, when that material is carbonised, a filament of even texture throughout, or does he get the *petites boules*.

Mr. CHARLES: No, he does not get the *petites boules*.

Mr. JUSTICE BUTT: I want to know whether this paper really means to say you get a continuous, regular filament over those substances.

Mr. CHARLES: I think I have got the witness's view. (To the Witness): I understood you to tell me that, looking at the last sentence, which commences with the words "spirit of wood," the filaments there mentioned in the last line refer to the filaments

mentioned in the last line but one, namely, those of one centimetre in length, constituting a kind of silky and frothy coke. My lord suggests that in the last sentence, "these filaments," mean all the threads as well as the filaments.—Certainly not. It specifically refers to the production——

Mr. JUSTICE BUTT: That answers my former question, but not my present one. I shall ask the professor sooner or later whether he could get anything more even and continuous from his linen and paper material than he would in that.

Mr. CHARLES: In the case of the thread there would be a fibrous foundation?—There would be what his lordship has seen, the basis of the carbon filament before, and there is the result afterwards.

The basis of the carbonised filament, of course, would be there?—And there you have the other filaments which he describes deposited on it with an irregularity of appearance.

Mr. JUSTICE BUTT: I understand he has stated that whether you take the material described in the last paragraph or the threads of linen or silk in the former paragraph, you will only get a filament, if you choose to call it a filament, composed of *petites boules juxtaposées.*

WITNESS: Perhaps I would make it clear if I explained to my lord the origin of these small balls. The ultimate deposition of carbon does not take place in one stage. There are a large number of intermediate bodies formed, and the ultimate substance that gives the carbon is of a bituminous character, and the consequence of it is that it is small quantities of bituminous material which is deposited, and during that time it is plastic, and as the gases give off from it and deposit carbon it grows in that way, and that is the reason he describes exactly what took place.

Mr. CHARLES: The question I put to you is this, whether the carbonised thread is not continuous?—If you mean the original thread of Sidot's process, certainly not. It is continuous in one sense, but not continuous in the electric sense.

Mr. JUSTICE BUTT: I understand your evidence to be this, that whether we take one of M. Sidot's materials or another the result is a filament, if filament it be, composed of *petites boules*?—That is what I mean.

Mr. CHARLES. That is your view?—That is the result of experiment. It is no view of mine.

I want to ask you a question about the irregularity of the thread produced. I use the word thread because I am dealing with the earlier part of M. Sidot's paper.—You mean the irregular result after the Sidot process?

Yes; it wants homogeneity; it is uneven?—It is uneven in form.

In other words, it is thicker in one place than it is in another?—Yes, it varies in shape.

Was not that one of the difficulties which, up to 1878, existed and prevented the use of carbon in an incandescent lamp?—Yes, the irregularity and the impurities in it.

Is there anything in Mr. Edison's patent which indicates that his process would produce a regular filament?—I am sorry to say I have not specifically studied Edison's patent.

Are you are aware, apart from Mr. Edison's specification, that since the reading of M. Sidot's paper a mode has been described of removing the irregularity of the carbonised thread?—I am.

Is there any reason, and if a reason, what is it, why the irregular carbonised thread which could be produced by following M. Sidot's process should not be made regular by the subsequent discoveries? In short, why should not the process of flashing be applied to M. Sidot's irregularly carbonised thread?—What do you mean by flashing?

Mr. JUSTICE BUTT: The process which has since been discovered.

Mr. CHARLES: Which is of making the thread homogeneous?—I say I am aware of the process, but I have not studied Mr. Edison's patent. I ask you what you mean by the word flashing?

What I mean is this, the process by which the carbonised thread or filament is made homogeneous.—You mean, I suppose, by electric incandescence in an atmosphere of these hydrocarbons? That is what you mean by flashing?

Yes.—Then I say that I believe and know that that can be successfully conducted.

Is there any reason why it should not be successfully applied to irregularly carbonised thread?—I think it would be ridiculous. It would make the thread very much worse than when you put it in, and consequently if you applied the new process to the result of Sidot it would simply be putting the cart before the horse.

I do not quite know what the right word to use is, but would not the process now known of making an irregular filament regular be a process which could be applied to Sidot's filament?—I am not prepared to say. I never tried it in a Sidot filament, and it would not be very easily done.

Mr. JUSTICE BUTT: Then you do not say whether flashing, as it is called, can be applied to a Sidot filament?—I can conceive it might be applied. I should think it very ridiculous, because Sidot's process makes the thread much more irregular than it was, to begin with.

Mr. CHARLES: What is there to prevent one of those carbonised threads, which you produced yesterday, being attached at either end to platinum, and a current of electricity passed through it in an atmosphere of carbureted hydrogen, which is the very process which produces regularity? Why should that not be done?—I never said it could not be done. I only said that is not Sidot's process.

I know it is not Sidot's process, because it was not used in the year 1870; but what I want to know is this, is there any reason in the world why one of these carbonised threads should not have a platinum wire attached to either end of it, and an electric current passed through it in an atmosphere of carburetted hydrogen?—If you wanted to do it, and there were any object, there would be no reason why it could not be done.

Mr. JUSTICE BUTT: That is Sidot's?—No; that is a filament before the Sidot process.

Mr. CHARLES: I am talking of the one after the process.—What was placed in my hands was one before. I did not understand that you meant after. I made a mistake in answering the question.

Why should not that be so?—I say there is no reason why, if you can get these filaments separate, you should not pass an electric current through it.

In an atmosphere of carburetted hydrogen?—Yes.

If that were done would not the irregularity disappear?—No; I think these filaments are far too irregular, both in the interior when you take a cross section, and in their outer forms, for any such process ever to produce a uniform conducting medium.

You have never, you told me, made such an experiment?—No; because I am quite certain it would be a failure.

Mr. JUSTICE BUTT: What is the reason?—From the great irregularity of both inside and out.

Mr. CHARLES: Is it a matter of degree of irregularity there that you rely upon?—Certainly, because the principle that you are going to apply depends entirely on a certain amount of irregularity; but in these Sidot's filaments you will observe that all these little ball growths are at right angles to the direction of the original filament, and there is such an amount of irregularity that instead of getting something of the diameter of your original filament, you would get something of five times the diameter.

The object of the process is to remove irregularities from this carbon filament, is it not?—That is what I understood you were asking about.

Mr. JUSTICE BUTT: He says it may be done with an ordinary carbon filament, but that it will not work what you seek to work out upon the filament treated by Sidot's process.

Mr. CHARLES: That is his opinion. He has not tried it. Will you kindly tell me what you did in making your experiment yesterday, because I do not feel that I have quite grasped it?—What I did was to follow the directions given by Sidot to deposit this conducting carbon by the method which he has described, inserting in a porcelain tube and passing a current of a vapour of hydro-carbon over it.

How long did you continue the process?—The process was continued for about three hours, that is to say, from the time of heating up the porcelain tube. You cannot insert it in a furnace and get it instantly hot.

Did you pass a vapour of a hydro-carbon over it?—I did.

Does Sidot do that?—He does.

Will you kindly point out where?—In the last paragraph.

I am talking of the earlier part. He says: "Wood spirit and hydro-carbons would behave exactly in the same way."—I have tried disulphide of carbon it that is what you want.

Turning to the last clause, "spirit of wood, carburetted hydrogen, &c., also changed a wood into carbon elastic and conductive." Does carburetted hydrogen there, in the chemical sense, mean hydro-carbon gas?—It means hydro-carbon gas, undoubtedly.

Not a vapour?—A vapour is a gas.

Did you begin with a carbonised thread?—I did. I carbonised it before I placed it in the porcelain tube.

Mr. JUSTICE BUTT: As I understood, he carbonised a hank of thread, and then with the half of it, he operated under Sidot's process, and produced that specimen. The one glass contains a half of the hank simply carbonised, and the other the hank treated by Sidot's process.

Mr. CHARLES: Then you put into Sidot's process a thread already carbonised?—I did.

Just look at what M. Sidot does: "I introduce into a porcelain tube little pieces of wood, across which I begin by passing the vapour," and so on. Is not this process really a process for the carbonisation of the thread, not for the treatment of a carbonised thread?—I wanted to give it the very best chance.

You began with a carbonised thread, and then put that through Sidot's process?—Yes.

Is not the process itself a process for the carbonisation of the thread?—I do not understand so. I think that his process is applicable to charcoal, or you may carbonise it if you please in a tube. It makes no difference; it only takes a longer time. I had only to heat it more gradually, and as time was not available I carbonised it previously, and used it in that form.

Mr. MOULTON: If your lordship will look at the paper you will see Sidot uses both methods. In the latter part of his paper he speaks of wood being *chauffé au rouge* before he passes the vapour over it.

Mr. JUSTICE BUTT: That is the wood. Mr. Charles is dealing with linen, cotton, and so on.

Mr. ASTON: The first process deals with "*petites faisceaux de bois.*"

Mr. JUSTICE BUTT: Then having said that, he says, I have obtained the like substances from certain other things, and it is those other things. Linen thread is the one Prof. Dewar has operated upon.

Mr. CHARLES (to witness): What hydro-carbon did you use?—Yesterday I used benzol vapour.

Is that a very highly carbonised hydro-carbon?—Yes, it contains a very considerable quantity of carbon. He does not

mention any hydro-carbon; he says hydro-carbons generally. Paraffin oil would have been the same thing.

Suppose you had used a hydro-carbon, such as marsh gas, would you not have got a less irregular filament than the one you did produce?—I cannot say. All I can say is, that I have tried with coal gas, which contains a very large proportion of marsh gas, and the deposit is of the same character as that described by Sidot.

Can you show me a specimen result which you obtained by coal gas?—No; but I can show you a result more remarkable. That deposit in the porcelain tube is done without the wood spirit. He describes this black growth of the filament as resulting from wood spirit, and that wood spirit contains actually 50 per cent. of oxygen.

You did not experiment on the thread with the wood spirit?—No.

(To be continued.)

THE STRANGE HISTORY OF A DYNAMO

As told by itself to

A. DYNAMICABLE.

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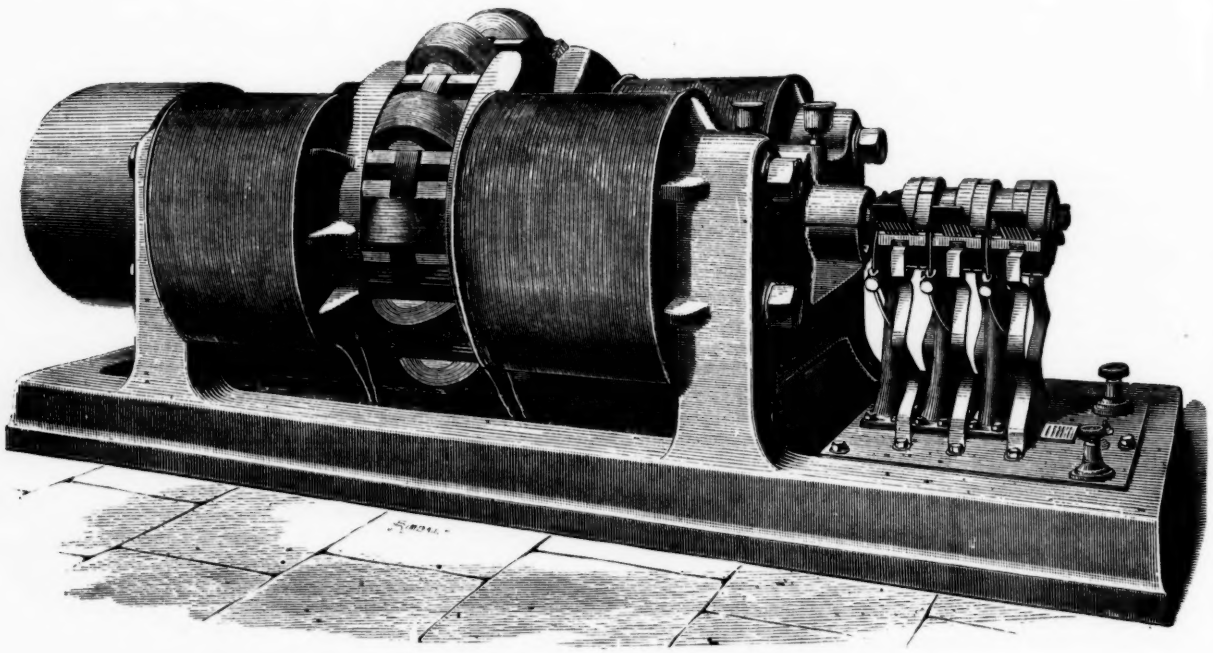
(*Continued from page* 518.)

A CASUAL glance, indeed, at the Brush machine is sufficient to indicate that so far as appearances go it has not much in common with the dynamos which I have already described to you, and I have intimated that its *modus operandi* differs from any of the foregoing. The collector is entirely different from that of Gramme or Siemens, somewhat resembling a number of Pixii or Clark commutators, in a modified form, grouped together on the end of the armature axle. I have previously said that the coils on the Brush armature do not form a continuous circuit, and, as a matter of fact, they are connected together in pairs, not consecutively, but each to that diametrically opposite it.

For each pair of coils there is a separate commutator, so that if a ring is wrapped with eight coils there are four distinct commutators, or for 12 coils six commutators, side by side upon the axle. This sketch represents the commutating arrangement employed for an armature of four pairs of coils, and although at first sight one might think there are only two, there are really four commutators corresponding to the four groups of coils; one pair of commutators being set 45° in advance of the other. The collecting brushes are so arranged as to touch at the same time the commutators of two pairs of coils, but not of two adjacent pairs, the adjacent commutators being always connected to two pairs of coils which lie at right angles to one another in the ring. By the aid of a diagram we shall be better able to understand the cycle of operations which go to effect the production of the current in the Brush machine. The thick black curved lines represent the parts of the commutators, N, S, the field magnets, and A, A′, B, B′, the collecting brushes, the connections from one side to the other being shown by the dotted lines.

Here the eight coils are, you observe, numbered as four pairs, each pair having its own commutator. To these are connected the outer ends of the wire composing each coil, and the inner ends which it is not necessary to show, are united to each other. In the actual machine each pair of coils as it passes through that part of a revolution in which there is least action, is cut out of circuit by causing the two halves of the commutator to be separated from one another by a short distance at each side. As shown to you here, the coils, 1, 1, are cut out of action, for neither of the two halves of the commutator touch the brushes. Coils 3, 3, are in the position of greatest action, and the powerful current induced in them flows out at brush A into A′. This latter is connected across to brush B, where the current re-enters the armature

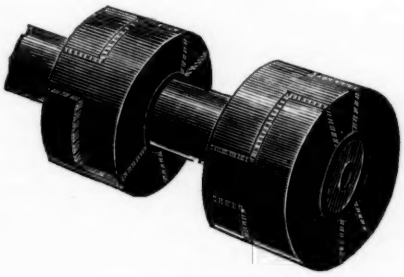


A BRUSH DYNAMO WITH A 12 COIL ARMATURE.

The coils, 2, 2, have just left, and coils 4, 4, are approaching the position of greatest action, and through both pairs, therefore, partial induction is going on. The current on passing into B divides, part going through coils 2, 2, and part through 4, 4, reuniting at B′, whence the current circulates round the coils of the field-magnets to excite their magnetism, then round the external circuit—usually composed of arc lamps—and back to A. Each set of coils will therefore during rotation be brought consecutively into the position of least action and be cut out of connection; and so the cycle of operations goes on.

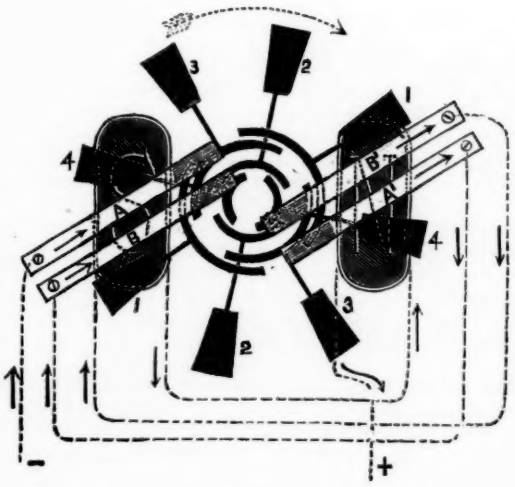
Whichever pair of coils is in the position of greatest action is delivering current direct into the circuit, and the two pairs which occupy the secondary position, such as 2, 2, and 4, 4, alluded to just previously, are always joined in parallel, *i.e.*, the same pair of brushes touch the respective commutators of both.

The four pairs of coils may be looked upon in the light of four separate machines delivering alternating currents to a commutator which changes them to intermittent currents in the same direction, the series being united into one ingenious system or whole.



BRUSH COMMUTATOR.

The doings of the Brush machine in this country are doubtless familiar to you. Its introduction was the signal for great advances in electric lighting, but the manner in which the system was commercially developed was productive of much evil, and, at the same time, of a little good.



CONNECTIONS OF BRUSH DYNAMO.

The next dynamo which must claim your attention is that constructed by Edison. This, in principle, will be far more easily grasped than that of which we now take our leave, for it goes much on the lines of Siemens, the principal points of interest lying in the method of coiling and construction of the armature, and in the massive field-magnets.

(*To be continued.*)

ON THE APERIODIC GALVANOMETER OF DEPREZ-D'ARSONVAL, EMPLOYED AS A BALLISTIC GALVANOMETER.

IF we seek the value of the proportion which exists between the constant deviation, a, produced by a permanent current of the intensity, i, and the impulse, δ, produced by the passage of a quantity of electricity, q, for the Deprez-d'Arsonval galvanometer, says M. Ledeboer, in *Comptes Rendus*, we are led to solve the differential equation which represents the movement of the coil. This equation may be put in the following form :

$$\frac{d^2\theta}{dt^2} + \frac{1}{R}\frac{\pi^4}{T^4}\frac{a^2}{i^2}\Sigma m r^2 \frac{d\theta}{dt} + \frac{\pi^2}{T^2}\theta = \frac{\pi^2}{T^2}\frac{a}{i} I.$$

when the galvanometer is traversed by a current of the intensity, I.

All the constants which enter into the equation, viz.:

R the total resistance of the circuit ;

$\frac{a}{i}$ the constant of the galvanometer ;

$\Sigma m r^2$ momentum of inertia of the movable coil ;

T duration of a simple oscillation with open circuit ;

may be directly determined by experiment. We may, therefore, solve this equation each time that the initial conditions are given.

The kind of movement depends on the roots of the characteristic equation. When the roots are imaginary the movement is oscillatory ; but when the roots are real the galvanometer is aperiodic, and the coil displaced abruptly by the passage of the quantity of electricity, q, returns to the position of equilibrium.

We obtain simple formulæ if we consider the limited case for which the roots of the characteristic equation are equal. The total resistance of the circuit which answers to this case is given by the formula

$$R = \tfrac{1}{2}\frac{\pi^3}{T^3}\frac{a^2}{i^2}\Sigma m r^2$$

To find in this case the impulse, δ, due to the passage of the quantity of electricity, q, it is necessary to solve the differential equation without the second quantity, with the initial conditions

$$t = 0\ \theta_0 = 0\ \left(\frac{d\theta}{dt}\right)_0 = \frac{\pi^2}{T^2}\frac{a}{i}q$$

We thus obtain the formula

$$\delta = \frac{a}{i}\frac{\pi}{T}\frac{i}{e}q$$

This condition is realised by the discharge of a condenser, the galvanometer being provided with a shunt such that the total resistance of the circuit is equal to R.

On removing the shunt we have an open circuit and the discharge of the same condenser, under these conditions gives place to a deviation, δ', given by the equation

$$\delta' = \frac{a}{i}\frac{\pi}{T}q.$$

Which gives for the ratio of the deviations the relation $\frac{\delta'}{\delta} = e = 2{\cdot}72$ the base of the Napierian logarithms.

The experimental verification of these formulæ has been made by the aid of two Deprez-d'Arsonval galvanometers, the one with a permanent magnet and the other with an electro-magnet. The limit of resistance thus obtained can only be observed with an approximation of 5 to 10 ohms. The following table contains the results of the experiments :

	Perm. magnet.	Electro-magnet.
Total resistance calculated ...	337 ohms.	515 ohms.
" " observed ...	337 "	523 "
Ratio observed	2·52	2·68
Theoretic ratio, e	2·72	2·72

The deviation between theory and experiment is mainly due to the inconstancy of the magnetic field. This constancy is greater in the galvanometer with the electro-magnet than in the permanent magnet.

Electric Light at Eastbourne.—The Corporation of Eastbourne proposes to light the new Town Hall, when opened, by means of the electric light. The building, which will be ready by October, is likely to be formally declared open by a member of the Royal family.

NOTES.

Electric Lighting of Edinburgh Exhibition.—Messrs. Andrews & Co. are lighting the machinery in motion section and the Old Edinburgh Street of the exhibition with 33 powerful Andrews arc lamps, which are connected in parallel circuits to two pairs of mains, one pair carrying 16 lamps and the other 17. Each section of lamps is connected to a separate Andrews dynamo, but the main wires are arranged so that the whole of the lamps can be run from one of the machines. Throughout the department the neighbouring lamps are on alternate circuits, and are arranged to produce the best illumination of the exhibits, and each one having a current of 25 ampères there is an abundance of light. The Old Edinburgh Street is lighted with one powerful lamp, suspended from a pole above the buildings, which casts a moonlight effect into the street. The machines working these lamps are Andrews' well-known slow speed dynamos, one, a large machine, weighing 3½ tons, and capable of supplying nearly double the whole number of lamps—running at a speed of 290 revs. per minute; and the other, a 35-unit machine, running at 400 revs. per minute.

Electric Lighting of the ss. "Dynamic."—Messrs. Andrews & Co. have just completed an installation of about 100 lights on board the ss. *Dynamic*, which has been under alteration by Messrs. Workman, Clark and Co. of Belfast. The current is supplied by one of Andrews patent dynamos, running at a speed of about 500 revs. per minute. The light has been distributed throughout every portion of the ship, with the exception of the signal lamps. Two clusters (portable) of three 50-candle-power lamps each are used to light the hatches when loading or discharging cargo. The fittings throughout have been manufactured by Messrs. Andrews & Co., and are of a thoroughly substantial character, and admirably suited to their various positions. The light in the saloon is especially brilliant, and the handsome nickled fittings give it a very effective appearance. One particular which is worthy of note is the despatch with which the electrical outfit has been completed, the vessel only having been laid up for a fortnight, and the trial of the electric light having been made with the most satisfactory results the night before she left the dock.

The company has also just completed the electric lighting of the second of three magnificent Atlantic steamers for the North German Lloyd, of which we hope to give a description hereafter.

Electric Lighting at Glasgow.—The minutes of the joint sub-committee of the Glasgow New Municipal Buildings Committee and Bazaar Committee, on the question of electric lighting, of date 30th April, contained the following note:—"The meeting had before them the question of the expediency of getting one place where the motive power necessary for lighting the New Municipal Buildings and the Bazaar Buildings and City Hall by the electric light could be produced, and after full consideration, were of opinion that the Bazaar Committee should endeavour to find accommodation in the new buildings now being erected by them for the production of the necessary power for lighting the Bazaar and City Hall by means of electricity, and also such additional power as would be required for lighting the New Municipal Buildings." Mr. Filshill, convener of the committee, said that from inquiries he had made from three or four different parties, he had found that the cost for lighting the City Hall and the Bazaar with electricity would be at the outside, £3,000. After the system had been fitted up and set thoroughly in operation, the probable saving of expense would be from £100 to £150 a year. Two or three years ago the council agreed to make the tenants of the Bazaar pay for the gas which they used. The result had been most unsatisfactory. Some of the tenants did not use the gas, and the consequence was that the Bazaar was very badly lighted. Although the matter had not been formally before the Bazaar Committee, they thought that if one system of lighting was introduced, and if electric lighting was found suitable, the improvement would be very great. The yearly expense of lighting the City Hall and the Bazaar with gas was about £500, and it was thought that it could be done by the electric light for £350 or £400. A saving of £100 or £150 a year would thereby be caused. He considered it a right thing for the council to make some experiment in regard to electric lighting, and the City Hall would be a very suitable building in which to make the experiment. The City Hall was much used in the autumn when the weather was still warm, and the gas used heated the building to an almost unendurable degree. The electric light would, in a great measure, remedy this, and, with the new system of ventilation, would greatly improve the City Hall. The £3,000 he had mentioned included the lighting of the entrances of the City Hall and Bazaar, and he was assured that when once the light was fitted up, no additional outlay would be required to keep it in order. He moved the approval of the minutes of the Bazaar Committee, including the minute of the Joint Sub-Committee on Electric Lighting. Mr. James Martin seconded the approval of the minutes. In doing so, he supplemented the remarks made by Mr. Filshill by stating that the sum of £3,000 included the cost of fitting up the New Municipal Buildings with the electric light. Bailie M'Laren thought that the Bazaar Committee should consider what should be done to improve the Bazaar by fitting it up with the best appliances for lighting with gas. In many of the Government offices the electric light had been discarded in favour of the improved system of lighting with gas, and the committee ought to bring forward estimates as to the cost of lighting with electricity, and with the improved system of lighting with gas. After some discussion, the minute of the Joint Sub-Committee on Electric Lighting was delayed, and Bailie Filshill was instructed to bring forward estimates for fitting up the Bazaar and City Hall with the electric light, and with an improved system of gas lighting. Bailie Richmond thought they should get a committee of gentlemen that were not tied up with the fact that they were Gas Commissioners, a committee that would look at the question broadly, and from which a fair and impartial judgment would be got.

The Electric Light and Gas.—In Temesvar, we read, the gas company reports a fall, but not a serious fall, in the consumption of gas since the electric light was started. The number of burners has increased by 12 per cent.

Dreadful!—Bishop Turner, of the African Methodist Church of Georgia, Kentucky and Tennessee, is reported to have said recently:—"I admire the great inventions of white men, and especially in controlling electricity; but the subjection of God's agent is carried too far in making it light the world. This has already changed the meteorology of our country. Look at the floods, hurricanes, cyclones and other atmospheric disturbances taking place in the heavens and upon the earth. I predict that the unbalancing of the air currents which electric lights are causing will in a few years, if they increase in numbers as fast as in the last five years, cause whole cities to be blown away at a time, and floods unlike any save Noah's."

Electric Lighting of the Birmingham Art Gallery.—The Birmingham Town Council has decided to accept the tender of Messrs. Chamberlain and Hookham, a local firm, for the plant required for the introduction of the electric light into No. 2 Art Gallery. The gallery contains the collection of oil paintings by David Cox, presented to the town by the late Mr. J. H. Nettlefold, and one of the conditions of the bequest was that the gallery in which the paintings were placed should be lighted by electricity. The amount of the tender is £560, and the annual cost of maintenance is estimated at £100. The power will be supplied by a gas engine.

Electric Lighting at Wentworth Castle. — The quarterly meeting of the Manchester District Institution of Gas Engineers was held last week, near Barnsley. Wentworth Castle, Stainbrough, the residence of Mr. T. F. V. Wentworth, was visited, and special attention was paid to the newly-erected machinery and apparatus by which the mansion is lighted by over 600 incandescent electric lamps.

Oriental Telephone Company's Claim for Royalty.—With reference to the claim made some time since by the Oriental Telephone Company for royalty on all telephones in use in South Australia, the Acting Postmaster-General (Mr. E. Squire) has informed us (the *South Australian Register*) that the Government have ascertained that all the telephones purchased by the local telegraph department have been manufactured under a special agreement made between Messrs. W. H. Masters and Co. and Mr. Edison, the inventor. The claim for royalty cannot therefore be enforced. Messrs. Masters & Co. would be prepared, if necessary, to protect the Government. Intimation to this effect has been given to the Oriental Telephone Company.

American Telephone Patents.—The latest developments of the Bell telephone controversy in America are as sensational as anything of which we have been before informed in the same connection. Zenas Fisk Wilber, the ex-chief examiner of patents for electrical subjects in the Patent Office, has filed another affidavit, declaring that much which he has previously sworn is false, and was extracted from him whilst he was "afflicted with and suffering from alcoholism." He is now desirous, he says, of making retribution for his past misdeeds, and of "righting a great wrong done to an innocent man." "I am convinced that by my action while Examiner of Patents Elisha Gray was deprived of proper opportunity to establish his right to the invention of the telephone ; and I now propose to tell how it was done." He then relates that he and one of Prof. Bell's patent agents had been brother officers in the Army ; that he had at various times borrowed money from this agent, notwithstanding a regulation prohibiting the borrowing of money from patent attorneys under any circumstances ; and that he was indebted to him, and under other considerable obligations to him at the time Bell's patent was applied for. He therefore felt anxious to favour him in his practice, and when he was instructed to determine, if possible, whether the application of Bell or the caveat of Gray was filed the earlier, he was desirous of finding that the Bell application was the earlier filed, and he did not make as thorough an examination as he should have done in justice to all concerned. So when he found in the "cash blotter" the entry of the receipt of Bell's fee ahead of the entry of the receipt of Gray's fee he closed the examination and determined that Bell was the earlier. After the suspension of Bell's application had been revoked Prof. Bell called upon him at the office, and he showed him the original drawing of Gray's caveat, and fully explained Gray's method of transmitting and receiving. On Bell's leaving, Wilber, by his own account, accompanied him into the hall, and there Bell presented him with a $100 bill. Prof. Bell, of course, denies the allegations made against him by Wilber, but the American papers say that there are inconsistencies in his statement now when compared with what he has previously said.

Fatal Fall from a Telegraph Pole.—Private Back, of the Royal Engineers, and a telegraph lineman, met with a shocking death at Newbury last Friday. He had walked from Marlborough inspecting the telegraph wires, and on reaching Newbury ascended a lofty telegraph pole near Northbrook Street, and was adjusting the wires when he slipped and fell, severely fracturing his skull, causing immediate death.

Cheaper Telegraphy.—It is announced that in consequence of the reduction in tariff by the cable companies, the subscription to the Anglo-American Telegraph Exchange, of 2, Copthall Chambers, is reduced to £3 3s. per month, or £30 per annum.

The Commercial Cable Company.—According to the *Electrical World*, Mr. George G. Ward, the general manager of the Commercial Cable Company, in New York, is receiving great encouragement in the fight his company is making against the "pool," and finds that the public support is both large and ready. It must be regarded as a fortunate thing for the Commercial Company, says our contemporary, that its interests here are in the hands of Mr. Ward, who is not only a faithful and careful executive officer, conversant with all the complex details of internal working, but enjoys remarkable popularity in the electrical profession and among the leading representatives of New York financial and commercial interests.

Fire Appliances at the Edinburgh Exhibition.—The different fire brigade stations within the Exhibition buildings were originally connected by means of mechanical telephones, but the working of these intruments having been found unsatisfactory, they have been superseded, at the request of the Exhibition Committee, by the National Telephone Company's system of fire alarms.

Volk's Electric Railway.—The Work's Committee reported to the last meeting of the Brighton Town Council, that they had determined to refuse permission to Mr. M. Volk for the construction of a passing place on the electric railway immediately east of the Groyne, opposite Charlotte Street. This refusal was attributed by Councillor Hall to a feeling of opposition to the electric railway altogether. The passing place which Mr. Volk proposed to construct was in a most convenient place. He reminded the Council that for the last two years the railway had carried passengers to the number of 250,000 a year, while the train mileage on the little line was 24,000 per annum. A discussion ensued, some of the speakers contending that the railway had been of benefit to the town, while others urged that it had obstructed public improvements and should be granted no further boons. Councillor Berry sarcastically remarked that he understood that Councillor Hall was one of a syndicate which was to purchase the railway, until the latter assured him to the contrary. Councillor Oliver Weston thought that Mr. Volk's "experiment" had had a fair trial, and should now be swept away altogether. Eventually the decision of the committee in refusing the application was reversed by 28 to 15.

Ryde Electric Railway.—At the annual meeting of the shareholders of the Ryde Pier Company, the directors reported that the above project had been finished at an entire cost of £1,300. The increased traffic and small working expenses justified them in congratulating the proprietors on the wisdom of their decision in adopting this mode of locomotion. Mr. George Garnett, who was largely instrumental in introducing electricity to the pier, retired from the board of directors, and he was warmly thanked by several speakers for his efforts on behalf of the company. Alderman Cudlipp remarked that Mr. Garnett, Mr. Gibbs, and himself were the trio who were bent upon introducing an electric railway—which they believed would be the future means of locomotion—into that part of the country. It had excited a great deal of interest and curiosity, indeed, he had heard an American say that they had nothing like it in the United States. A recent letter from Venice showed the directors that the fame of their new venture had travelled to the famous old city of the Adriatic.

Cricket Match.—The employees at the Manchester and Liverpool centres of the Lancashire and Cheshire Telephonic Exchange Company, played a cricket match at Liverpool on Saturday last, and after a pleasant game the visitors won, scoring 56 runs against their opponents' 40. The Liverpool team aferwards entertained the victors at dinner.

Hopkinson's Electrical Hoist.—Our description of this invention, given last week, was taken from the *Mechanical World*, and not, as inadvertently stated, from the *Mechanical Engineer*.

Transmission of Power by Gearing.—At the Boston meeting of the American Society of Mechanical Engineers last year, Mr. Wilfrid Lewis, of Philadelphia, read a paper on "Experiments on the Transmission of Power by Gearing." These experiments which were most elaborately carried out, were made by Messrs. William Sellers & Co., and are published in the June number of the journal of the Franklin Institute. They showed conclusively the advantage of spur gearing over all other kinds in point of efficiency and durability, for not only is there less friction, and consequently less wear, but the wear in spur gearing is distributed over a great deal more surface.

The Jablochkoff and General Electricity Company, Limited.—Some inaccuracy has been pointed out to us in a note which we published last week respecting an action which Messrs. Shippey Bros. brought against the Jablochkoff and General Electricity Company for payment for certain incandescent lamps. Our note was headed "How to Elude Payment," and, from the language used by the judge, we thought this a suitable heading; but the report upon which our note was based did not sufficiently relate the facts of the case, so as to make clear that the lamps sued for were not supplied to the present Jablochkoff Company, but to a former company bearing a somewhat similar name, which went into liquidation, and which sold its business to the new company by leave of the Court of Chancery. Mention was also made of the medal awarded to the present company at the Inventions Exhibition, the award being, as was stated, for the incandescent lamps of Messrs. Shippey Bros. This statement is inaccurate, the award in fact having been for the Jablochkoff system of electric lighting.

Adelaide Jubilee Exhibition.—We have received from Sir Samuel Davenport, the South Australian Agent-General, a publication relating to the Jubilee International Exhibition, which is to be held at Adelaide next year. The age of the colony is co-eval with the reign of her Majesty, Queen Victoria, and the exhibition will be opened on June 20th, on which date her Majesty will have reigned fifty years. Active steps are being taken to ensure the success of the undertaking, a number of sectional committees having been already appointed in Adelaide, while the Government will also appoint a London commission to assist the promoters in organising the exhibition. According to the prospectus, Section B of Department III. (Education and Science) will be devoted to the exhibition of scientific and philosophical instruments and methods. Class 358 in this section will embrace: instruments of precision and apparatus of physical research, experiment and illustration, astronomical instruments, geodetic and surveying instruments, nautical astronomical instruments, levelling instruments, &c. Class 361: chronometers, astronomical clocks, electric clocks, &c. Class 362: apparatus for artificial illumination, including electric, oxyhydrogen and magnesium light. Class 363: telegraphic instruments and methods, batteries and forms of apparatus used in generating electric currents for telegraphic purposes; conductors and insulators and methods of support, marine telegraph cables; apparatus for transmission, keys, office accessories and apparatus; receiving instruments, relay magnets; local circuits; semaphoric and recording instruments; codes, signs, or signals; heliographs; printing telegraphs for special uses; electrographs; apparatus for automatic transmission; telephone, microphone, &c. Class 364: musical instruments and acoustic apparatus; phonographs, &c. Pending the appointment of a commission in London, information concerning the exhibition may be obtained through Mr. H. J. Scott, South Australian Court, Colonial and Indian Exhibition.

Military Apparatus for Electric Lighting.—An article by Captain Colson extracted from *Mémorial de l'officier du Génie*, appears in No. 11 (last month's issue) of the *Revue Internationale de L'Electricite*. The *matériel* described consists of two types of apparatus. (1) For a light of 2,500 carcels; and (2) for 600 carcels. There are numerous illustrations accompanying the paper.

The Cruto Lamp.—We are requested to state that the Cruto glow lamps are now kept in stock by the English agents, the Globe Electrical and Engineering Company, 20, Dartmouth Street, Westminster.

Railway Contracts.—Reference having been made under this heading, in a former number, to the London and North Western Railway Company's contract for electrical stores, the Globe Electrical and Engineering Company asks us to add that it has obtained the portion relating to carbon battery plates and accessories.

Perpetual Motion again!—Our New York namesake publishes, apparently quite seriously, the following:—"Among the wonders that attract the attention of the scientific public is that of the Gray dynamo-electric machine. It is claimed that tests have shown that this machine gives enough current for six 2,000-candle-power lamps for one mechanical horse-power. It is the intention of the inventor to utilise this current in suitably constructed electric motors, and thereby to obtain 4 to 5 horse-power from the motors to 1 horse-power used in driving the dynamo. A portion of the power generated by the motors is utilised in driving the dynamo, it being only necessary to start the dynamo at first by some outside force. It is expected that this system will be applied to the moving of trains, steamboats, &c."

"Father Petroleum"—Says *Invention*: "We were in hopes, when the 'Spiel' Petroleum Engine was some time ago introduced into this country, that the new invention would be actively pushed into actual use, and that it would prove a formidable enemy to the 'Otto' gas engine monopoly. As yet, unfortunately, our hopes have not been realised, and the 'Spiel' Petroleum Engine Company, which was formed to work the engine, appears to be more occupied with further promoting schemes than with the practical introduction. It appears almost as if the 'Father Brush' operations in subsidiary companies were to be repeated, only petroleum being father in this case." Then reference is made to the recent meeting of the company, reported in our last issue, after which our contemporary adds:—"As long as the engine is promptly introduced at reasonable prices, we would not begrudge the shareholders a good profit; but a different policy ought to be adopted if the primary object of the company—that of effecting the sale of a large number of engines in this country—is to be achieved."

Here is a chance for the "Etéve" petroleum motor which should not be allowed to pass.

Good Showing for a Primary Battery.—Messrs. Laing, Wharton, and Down, of London, write to the New York *Electrical Review* as follows:—"We note Dr. A. V. Garrett's speech before the National Electric Light Convention, appearing in your issue of February 27th, and, as we have an experience extending to over 2,000 lights running off primary batteries, we may feel justified in saying that it will be rather difficult for him to show better results than ours. The operating expenses are, here in London, five shillings per charge for solution for battery which will run twelve to fifteen eight candle-power lamps (Swan) for a total of 180 to 210 lamp hours the variation being due to the state of cleanliness of the batteries and proper attention to the amalgamation of zincs. To this figure about one shilling must be added for zinc consumed. This gives, you see, $1.50 for 200 lamp hours. and we shall be glad to have a comparison of results."

Dynamo Armatures.—We hope to publish very shortly an article on "A Comparative Study of the Performance of Armatures of Dynamo Machines." The author refutes the idea which is so prevalent, that the under portion of the coils on a ring armature is so much idle wire.

Telegraphing the Result of the Division.—Between half-past one and half-past two on Tuesday morning over seven hundred and seventy messages were despatched from the telegraph office at the House of Commons.

Electric Locomotion.—We understand that Mr. Elieson will shortly have six of his electric locomotives in operation for tramcar propulsion. We hope that nothing will be left undone to obtain accurate data of working cost, for if it can be shown beyond dispute that electrical energy comes out much cheaper than horse traction, this will do more to arouse the interest of the commercial man than any amount of writing on the subject can ever hope to accomplish.

Incandescent Lamp Patents.—What steps are the makers of incandescent lamps taking with respect to the recent judgment declaring Messrs. Woodhouse and Rawson to be infringers of the Edison patent? We hear rumours of meetings, or projected meetings to discuss the matter; but, so far, nothing definite appears to be forthcoming.

How to Wind Magnets.—The interesting series of articles written by Mr. Carl Hering, with the view of showing how to wind magnets for series, shunt, and compound machines, comes to an end in our present issue. These papers, as we have previously intimated, have been republished from the pages of the *Electrical World* of New York.

Secondary Battery Patents.—In reply to a query which appeared in our "Notes" columns last week, we have been informed that the B.T.K. secondary battery patents have just become the property of a gentleman who is also largely interested in the E.P.S. batteries. We cannot guarantee that this information is correct, but until refuted we have no reason to doubt the accuracy of our informant.

Schanschieff's Battery.—About the middle of January last, M. Criquebeuf tested a battery of eight elements in the laboratory of M. Hospitalier, and we have seen the results obtained plotted down in curves, so as to give a graphic representation of the performance of the battery. The external circuit was composed of a 10 volt Swan lamp, and a resistance of 0·1 ohm, which was used for measuring the current. The difference of potential, 11·25 volts, remained constant for a period of six hours, as did the current 0·8 ampère. At the end of eight hours the difference of potential had dropped to a little under 9 volts, and the current to 0·6 ampère.

Electric Fuzes.—The fuzes devised by MM. Scola and Ruggieri appear to show a decided advance in the direction of safety in mining operations. M. Ducretet's arrangement for testing them and ascertaining their condition is also very ingenious.

Dermatine.—This "improved substitute for gutta percha" is composed of gum, resin, turpentine, petroleum, or any spirit solvent, flower of sulphur, vegetable oil—for preference, castor oil, and oxidized calophon or other bituminous substance. This is thoroughly mixed and dissolved by heat. The inventor then mixes it with vegetable albumen or extract from lichen, previously dissolved in methylated spirit and ammonium. When the whole is thoroughly incorporated, he pours in tannic acid dissolved in aqueous solution. The whole is then boiled again, india-rubber or gutta percha added. The patent specification is dated 9th March, 1882, No. 1153.

The "Cornell" Tangent Galvanometer.—Prof. Anthony's paper on the Cornell Galvanometer, recently read before the American Institute of Electrical Engineers, serves the purpose of drawing attention to a fact of considerable importance. The indications obtained by the use of the voltameter appear to be liable to considerable variations from causes beyond control, and hence the voltameter must be used with extreme precautions. It was also pointed out that in practical operations the existing tables, even of modern date, relative to the quantity of metal deposited in a given time, were frequently found to be at variance with observed facts. If we examine this question more closely we may perhaps find a reason for these discrepancies in the fact that the tables published are not accompanied by details necessary for accurate comparison. These details ought to include the electromotive force employed, the nature of the solution, and, above all, the density of the current. Variations of these factors greatly vary the molecular nature of the metallic deposit, which naturally influences its specific gravity and thus affects the results. It would seem advisable, therefore, to conform as nearly as possible to the conditions of the experiments upon which the tables are based. Unfortunately, as stated before, these are not always to be found. Still, when we are told that experiments carried out under precisely similar conditions give discordant results, we must admit, says the *Electrical World*, that the question requires more study and further investigation.

An Improved Thomson's Little Siphon Recorder.—Mr. England, of the Mexican Telegraph Company, has forwarded to us a description and illustrations of improvements which he has effected in this instrument. We hope to publish these at a near date.

Serious Gas Explosion.—Captain Shaw, in his official report of Wednesday morning, gives the details of a serious gas explosion which occurred at 104, Inverness Terrace, Bayswater, at the private residence of Dr. H. Myriantheus, the Greek Archimandrite. An escape of gas had been noticed for some time, and suddenly a terrific explosion occurred on the second floor. Both rooms and their contents were wrecked, and the whole of the house more or less damaged, but a fire which followed was speedily subdued by the firemen, with the aid of the police and the inmates. Dr. Myriantheus was seriously burnt on the hands, face, and arms.

Transmitting and Recording Sounds by Means of Radiant Energy.—A recent patent issued to Alexander G. Bell, Chichester A. Bell and Sumner Tainter, of Washington, describes a new method for throwing a beam of light or other radiant energy into vibrations corresponding to sound waves, and also a method of producing a photographic record of such vibrations. The vibrations to be impressed upon the radiant beam are produced in liquid in motion, and this fluid impresses the vibrations upon the radiant beam. For this purpose special application is made of what are termed "sensitive jets."

Electric Locomotion in the States.—The Street Railway Committee of the Massachusetts Legislature, which visited New York, in May, is said to have been highly pleased with the motor tests it saw. Rumour has it that a report will be made in favour of an elevated electrical railway, with one row of posts, for Boston.

The Lead given to Brushes.—It is often stated on high authority that the cause of the lead which must be given to the brushes of a dynamo is due to a sluggishness in the demagnetisation of the iron core of the armature. It has been very clearly shown, however, in Professor Silvanus Thompson's "Dynamo-Electric Machinery," that the lead is not due to the cause assigned above but to the diagonal direction of the resultant magnetisation produced between the field-magnets and the armature.

Ship Lighting.—Messrs. Henry Bennett & Co. have secured the lighting of the new passenger saloon steamer *Victoria*, launched recently from the yard of Messrs. Blackwood and Gordon, Port Glasgow. This steamer has been built to the order of Captain Campbell of Wemyss Bay, and when completed will rank as one of the finest saloon steamers on the Clyde. It is well known that there are no saloon steamers afloat to equal those which ply between Glasgow and the many watering places on the Firth of Clyde, but to Captain Campbell deserves the credit of being the first to light his steamer throughout with the electric light. We have no doubt the other steamboat owners will, in time, follow Captain Campbell's lead in this matter, and we wish the gallant captain every success in his new enterprise.

The Electric Lighting Committee.—Having held several unusually secret and exclusive sittings, the Select Committee of the House of Lords on the three Bills introduced this Session to amend the Act of 1882, have now presented a report, in which they recommend that the Bills of Lord Bury and Lord Rayleigh should not be proceeded with, but that the Government Bill which Lord Houghton brought in should be adopted, with certain amendments. These amendments are not yet obtainable, nor is the report itself yet printed, but we understand that the amended Bill does not very materially differ from the original measure.

Ships' Compasses.—The variation of the needle, says Sir Thomas Browne, "may proceed from mutations of the earth, by subterraneous fires, fumes, mineral spirits, or otherwise; which, altering the constitution of the magnetical parts in process of time, doth vary the variation of the place." Had the nobly-eloquent exploder of "vulgar errors" lived in these days, says the *Daily Telegraph*, he would have added others to his list of the causes of the deflection of the needle; and not the least strange item in the catalogue would be the wearing of electric belts by rheumatic or debilitated sailors. "One of our crew here," writes the master of a steamer at Smyrna, "has a magnetic belt. I got it from him one day last voyage, and, taking it on the bridge, I found that all three compasses were very much affected by it; in fact," adds the captain, "the highest compass of the three went reeling round and round." The moral he desires to point is that as—so at least he says—these belts are much worn by seafaring men, and firemen in particular, masters should be careful to find out what magnets their crew or passengers may happen to have with them, "either in the shape of belts or in any other form;" for, as he justly asserts, errors in the compass lead the seaman at times into terrible accidents.

Finsbury Technical College. — The students of Finsbury Technical College intend holding their second annual conversazione at the college on the evening of July 2nd.

NEW COMPANIES REGISTERED.

Kensington Court Electric Lighting Company, Limited.—Capital £10,000 in £5 shares. Objects: To generate, produce and apply electricity for purposes of lighting, heating and motive power. Signatories (with 1 share each): James Swinburne (electrician); H. J. Dowsing (electrician), 4, Queen Victoria Street; W. A. Chamen (electrical engineer), 4, Queen Victoria Street; R. E. Crompton (electrical engineer), Chelmsford; W. T. Wakeford, S. Jordan and G. R. Ryder, 11, Great George Street, S.W. Registered 5th inst., without articles of association, by Messrs. Goodhart and Medcalf, 11, Great George Street.

Bright Platinum Plating Company, Limited.—Capital £1,800 in £1 shares, with power to increase. Objects: To purchase the invention of Mr. Wm. Arthur Thoms for improvements in the deposition of platinum by means of electricity, for which provisional protection (dated 1st April, 1886, No. 4,553) has been granted. Signatories: A. E. Sarti (electrician), 108, St. Paul's Road, Canonbury, 100 shares; A. W. Herve, 152, Farringdon Road, 100 shares; H. Parminter, 27, Clement's Lane, 100 shares; F. Wingrove, 33, Aschurch Grove, Shepherd's Bush, 25 shares; H. A. Réne Moén, 38, Old Jewry, 200 shares; R. Sawford, 6, Wharton Terrace, West Kensington, 100 shares; R. Parminter, 6, Sunninghill Terrace, St. John's, S.E., 25 shares. The signatories are to appoint the first directors, qualification 100 shares. The directors will be entitled to such remuneration as may be appointed at the statutory meeting. Registered 8th inst. by Mr. G. Twynam, 35, Bucklesbury, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Woodhouse and Rawson Electric Supply Company of Great Britain, Limited.—The statutory return of this company made up to the 4th inst., was filed on the same day. The nominal capital is £100,000 in £10 shares. 2,007 shares have been taken up, and upon 7 of these the full amount has been called and paid, the remaining 2000 being considered as fully paid.

Electric Recuperative Gas Lamp Company, Limited, (Clark's Patent.)—This company was dissolved under clause 7 (4) of the Companies Act, 1886, by notice in the *London Gazette*, dated 1st June, 1886. It was registered 29th May, 1885, with a nominal capital of £27,000 in shares of £20 and £10 each, but has not carried on business, no shares having been taken up.

CITY NOTES.

United Telephone Company, Limited.—The directors have decided, subject to audit, and after making ample provision for depreciation, &c., to recommend at the forthcoming general meeting a dividend for the second half year ending April 30th last at the rate of 9s. per fully-paid share, part paid shares receiving in proportion, making with the interim dividend paid on November 13th last, a total dividend for the 12 months ending April 30th last of 13 per cent. per annum, carrying forward a substantial sum to reserve.

Brazilian Submarine Telegraph Company, Limited.—The directors of this company have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended March 31st, 1886, and payable on the 24th inst. The books of the company will be closed from the 17th to the 23rd inst., both days inclusive.

West African Telegraph Company, Limited.—Application has been made to the Stock Exchange Committee for the appointment of a settling day, and the granting of a quotation for the shares of this company.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of May was 5,744, estimated to produce £3,030, against 4,474 messages, producing £3,736 in the corresponding month of last year. The receipts for the month of February, estimated at £2,750, realised £2,771.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 31st May are £2,988, as compared with £3,802 in the corresponding period of 1885. The February receipts, estimated at £5,034, realised £5,000.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending June 4th were £2,093, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Great Northern Telegraph Company, Limited. The receipts for May, 1886, were £22,480; from January 1st to May 31st, 1886, £100,960; in the corresponding months, 1885, £118,000; and of 1884, £106,760.

The Eastern Extension, Australasia and China Telegraph Company, Limited. The receipts for May amounted to £41,047 against £50,016 in the corresponding period of 1885.

The Eastern Telegraph Company, Limited. The receipts for May amounted to £50,741, against £61,327 for the corresponding period of 1885.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending June 4th amounted to £2,600.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending May 31st, were £3,450.

NEW PATENTS—1886.

7376. "Automatic regulators for electric currents." V. NOWAK. Dated June 2.

7394. "Electrical conductors." P. M. JUSTICE. (Communicated by E. G. Acheson.) Dated June 2. (*Complete.*)

7405. "Applying electro-motors to vehicles." M. IMMISCH. Dated June 2.

7407. "Electric fuses for pyrotechnic and other purposes." A. M. CLARK. (Communicated by H. J. Smith.) Dated June 2. (*Complete.*)

7426. "Producing ferricyanides of potassium, sodium, and ammonium, by electrolysis." C. PETRI. Dated June 2. (*Complete.*)

7440. "Winding and connection of dynamo-machines with accumulators." T. PARKER. Dated June 3.

7456. "Electro-magnetic marine governor." G. A. SMITH. Dated June 3. (*Complete.*)

7463. "Electro-chemical etching process." H. E. P. DORN. Dated June 3.

7474. "Secondary batteries." W. T. WHITEMAN. (Communicated by R. J. Gülcher.) Dated June 3.

7478. "Electric lamps." S. P. THOMPSON. Dated June 3.

7479. "Turning the current on to and from incandescent electric lamps." T. MACE. (Communicated by the Vitrite and Luminoid Company.) Dated June 3.

7481. "Binders or fasteners for securing telegraph wires." J. MILNE. (Communicated by the Sydney Telegraph Department.) Dated June 3.

7544. "Dynamo-electric machines." H. J. SMITH. Dated June 4. (*Complete.*)

7548. "Testing stations for use in connection with conduits for electric wires, &c." H. H. LAKE. (Communicated by J. F. Munsie and H. N. May.) Dated June 4. (*Complete.*)

7561. "Electrode." J. and F. M. GIBSON. Dated June 5.

7576. "Dynamo-electric machinery." J. A. KINGDON. Dated June 5.

7592. "Completing and breaking electric circuits." W. H. SCOTT, E. A. PARIS. Dated June 5.

7593. "Automatically breaking electric currents." W. H. SCOTT, E. A. PARIS. Dated June 5.

7596. "Elements for secondary batteries or accumulators." J. PITKIN. Dated June 5.

7636. "Preparation or manufacture of negative elements for voltaic batteries." D. G. FITZGERALD. Dated June 7.

7669. "Electric generators." E. T. and D. HIGHAM. Dated June 8. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

4992. "Improvements in the construction and arrangement of electric lamp fittings." T. TAYLER SMITH. Dated April 22. 8d. The object of the present invention is to still further increase the range of utility of an electric lamp or lamps, and to enable one or more of such lamps to be used in a variety of useful ways, such, for example, as a hanging lamp or as a table lamp, or as a bracket lamp, the same single flexible cord serving to convey the current thereto in each case. The invention also relates to means for arresting the movement of the flexible cord in its passage through its guide when the desired length has been drawn out, and to a switch of small dimensions by which the current passing through the cord can be controlled by one hand in the act of drawing out the cord or letting it be wound up.

5627. "Improvements in apparatus for transmitting and collecting currents in electric tramways and railways." M. H. SMITH. Dated May 7. 1s. 1d. According to this invention the electric collectors or runners, instead of running upon or against the conductors as before, run under them, and are flexibly attached to the outer skid or trolly, which runs upon the surface of the road.

6313. "Improvements in apparatus for lighting gas by electricity, applicable also for other purposes where ignition by the induction of static electricity is desired." C. L. CLARKE and H. J. COATES. Dated May 23. 8d. This invention relates particularly to improvements in the construction of various parts of electric gas-lighters, wherein the ignition is obtained by means of that class of static inductive generator known as the "Voss," "Varley," and "Wimshurst" machines.

6964. "Improvements in electric batteries." G. F. REDFERN. (Communicated from abroad by J. B. Neyraud, of Lyons.) Dated June 8. 6d. Has for object to prevent the sodaic water (that is to say water saturated with a salt) at the bottom of the porous pot from rising by the capillary attraction of the porous pot to the upper part thereof, and also to prevent the head, or screw, from becoming oxydised, and by these means to attain regular working and a much greater constancy. In carrying out the invention the inventor provides a battery, the porous pot of which is provided with a porcelain or earthenware cover or head glazed at the upper part. This cover is provided with a nipple having a conical hole also glazed; this hole is stopped by a lead plug in which is fixed a screw threaded rod serving as a connection, and provided with a nut. The lead plug is traversed by a platinum wire, which also passes through a suitable insulating material, sealing the plug; the wire is connected to a piece of carbon placed in the interior of the porous pot and surrounded by small pieces of similar material; the bottom of the porous pot is formed of insulating material.

6971. "An improved system of heating by electricity." N. FRERE. (Communicated from abroad by A. Elu and E. Courcelles, both of France. Dated June 8. 8d. The object of this invention is the introduction of an improved method of converting the electric energy of a current into heat, by varying, in the direction of reduction, the sectional areas of the circuit, as well as interposing therein different metals selected for their heat conducting power.

7114. "Improved construction of Gramme armatures for electric generators and motors." G. E. DORMAN. Dated June 11. 8d. Consists in mounting the armature, or the core of the armature, on a number of narrow pulleys, partly or wholly made of non-magnetic metal, insulated from one another except at the spindle hole, strung and keyed on a shaft, and screwed together by nuts on the shaft, or bolted with insulated bolts.

7194. "Electro-hydraulic vacuum apparatus." B. J. B. MILLS. (Communicated from abroad by C. Diener and C. A. Mayrhofer, both of Vienna.) Dated June 12. 8d. This invention has for its object to provide means for working, by the aid of vacuum produced in a system of pipes, any number of apparatus, arranged at the ends of the branches of said system, and being either clocks to be wound up and controlled, or railway signalling or other apparatus. According to the invention this object is attained by means of an apparatus which, by electric or other impulsions, establishes communication between a conduit containing steam or a liquid under pressure, and an ejector, which, when acted upon by the steam or liquid under pressure, exhausts the air from the pneumatic pipes, whereupon the vacuum made exerts a second impulsion upon the apparatus, having for its consequence that the aforesaid communication is cut off again and atmospheric air is admitted into the pneumatic pipes.

7373. "Improvements in electric vibrating bells." W. R. WYNNE. Dated June 17. 6d. Consists in providing a contact lever for making and breaking the electrical circuit. This contact lever is made with projections by which it may be moved by a piece attached to the armature and is so pivotted as to remain in position until moved by the movement of the armature and the armature must move a considerable distance before it can move the contact lever. The power of the magnet is thus more effectively utilised and a longer stroke is given to the hammer.

7694. "Improvements in printing telegraphs." W. H. DAVIES. (Communicated from abroad by G. B. Scott, of Brooklyn, New York.) Dated June 23. 8d. This invention has for its object improvements in printing telegraphs, and it applies to a printer in which the step by step rotation of the type wheels is controlled by short electrical impulses alternately of positive and negative polarity.

7799. "Improvements in telegraphy and telephony." C. LANGDON-DAVIES. Dated June 26. 8d. Relates to apparatus on the Van Rysselberghe principle in which in place of condensers an instrument termed a phonopore is used, and which consists essentially of two insulated wires laid side by side and together wound upon a reel or made into a bundle in any convenient manner. One of these wires is placed in electrical communication with the transmitting key and the other is connected to earth, but by neither wire is the circuit completed. Such an arrangement when the wires are suitably insulated and arranged yields greater advantages than has heretofore been obtained by the use of condensers, and the instrument is not liable to injury by electric storms or earth currents.

8122. "Improvements in electro-telephonic transmitters." A. A. CAMPBELL SWINTON. Dated July 4. 8d. The inventor so connects the microphone proper, upon which the sound waves act, to the case or support of the instrument that vibrations communicated to the latter do not in any way affect the said microphone proper which is therefore only acted upon by the direct atmospheric sonorous vibrations. This is effected by mounting the microphone proper in a massive or ponderous frame or support of lead or other equivalent material of great inertia and high specific gravity, and in some cases by suspending the said frame or support by means of springs or bands of India-rubber or other elastic substance, or mounting it upon layers or washers of felt or other suitable non-sonorous material.

8228. "Improvements in voltaic batteries." H. I. HARRIS. Dated July 7. 8d. A wooden box six inches square by six inches deep is divided by vertical partitions into four compartments, forming four cells of equal capacity, and the inner sides of the said cells are coated with paraffin or other suitable substance in the usual way. A porous cell five and a half inches long by one and a half inches diameter, provided with a flange or foot at the bottom is placed in each wooden cell and paraffin being poured into the bottom of the cell, holds the said porous cells firmly in position, so that the battery may be inverted without affecting them. The battery is provided with a wooden cover faced with sheet India-rubber and held down by bolts and nuts or other suitable devices, and the tops of the porous pots being flush with

the tops of the wooden cells, the various compartments and cells are effectually sealed. Four carbon rods five inches long, by three-eights of an inch diameter are held firmly by one end in holes in the said cover and enter the porous pots, and four brass screw clips, also affixed to the cover, hold zinc cylinders two inches diameter by four inches deep, which dip into the wooden cells and surround the porous pots. The battery is charged with the following ingredients; eight parts of sulphuric acid are added to eight parts of water and sodium nitrate is dissolved to saturation therein, one part of potassium bichromate is then added and the resulting solution is placed in the porous cells. The outer cells are charged with one part sulphuric acid to sixteen parts of water.

8452. "Improvements in telephonic apparatus." J. MUNRO. Dated July 13. 6d. The main object of these improvements is to provide a self-adjusting metal microphone transmitter and overcome the irregularity of working, which is a drawback to the use of metal contacts in telephone transmitters. This is done by the use of several balls, or other rolling bodies, free to roll on the electrodes between which they convey the current. The electrodes may take the form of rails or wires, with the balls, cylinders, or other rolling bodies, supported by and between them, or of plates above and below the rollers. If only one plate or electrode above or below is used, the balls or rollers should be connected together so as to roll in company.

8538. "A system of electric clock with automatic electric winding apparatus." D. VAN DE PLANCKE. Dated July 14. 8d. Relates to a system of electric regulator clocks, in which is produced an instantaneous closing and interruption of electric currents for the purpose of causing intermittent currents to pass over to different receiving dials, and at the same time to wind up the clock automatically.

8540. "Improvements in voltaic batteries." F. H. W. HIGGINS. Dated July 14. 8d. The inventor employs in voltaic batteries compound lead plates; they are formed with a series of rectangular or other perforations, which taper and are larger on the inner face of the plate than on the outer; the partitions between the perforations being reduced to a knife edge on the inner face of the plate. The perforations in the plates are filled with oxide of lead paste. The plates are fixed together face to face, and on account of the tapering form of the perforations the composition cannot escape from them—the plates are then further prepared by exposing them to the current of a battery, or of a dynamo-electric machine. These negative plates are employed in conjunction with positive plates or bars of pure zinc cast upon a wire of galvanised iron, which should extend to the end of the zinc. The zincs are amalgamated and placed within porous cells. The negative plates are on the exterior of the porous cells, and one or more may be contained in the same outer cell or vessel. The liquid made use of is such that the lead does not pass into solution.

11699. "Improvements in instruments for measuring electric currents." B. M. DRAKE and J. M. GORHAM. Dated October 1. 6d. A steelyard is first balanced in the ordinary way by sliding the weight to zero and the weight is then drawn along the scale and again balanced by the magnetic attraction of an electro magnet or solenoid round which the current, or a portion of the current to be measured, passes. The magnetic attraction is, therefore, balanced against gravity, and the scale of the steelyard gives the value of the current to be measured in ampères or volts, the winding of the wire being arranged to suit the requirements of an ammeter or voltmeter.

1886.

1160. "Improvements in smelting ores by means of electricity, and in apparatus or furnaces therefor." W. P. THOMPSON. (Communicated from abroad by A. H. Cowles of America.) Dated January 26. 8d. Consists in the improved method of operating incandescent electric furnaces, and in the combination with a furnace containing a charge of electrical resistance material, of two movable electrodes situated at opposite ends of the furnace, and projecting into the body of the charge contained within it, so that the said electrodes may, when the resistance runs down, be drawn apart, thereby increasing the amount of the charge between the electrodes, and consequently increasing the resistance, and thus preserving a uniform resistance within the furnace. The invention also consists in the arrangement of suitable mechanism actuated by the current, or a portion of the same, for automatically moving the electrodes, so as to govern the amount of energy utilised in the furnace.

1493. "Improvements in dynamo-electric machines and motors." H. J. ALLISON. (Communicated from abroad by W. L. Voelker, of America.) Dated February 2. 8d. Relates chiefly to the construction of the body of magnetic material upon which the coils of wire for the armature of the machine are wound or carried. It has heretofore been proposed to make this portion of the machine, which portion is usually of cylindrical or annular form, from a number of plates of iron put together to form the armature core or body. The object of this construction is to obtain a subdivision of the mass of iron, so as to permit more rapid changes of magnetic condition, and to prevent the flow of induced or Foucault currents in the body of iron, and to, therefore, lessen the heat developed in the armature.

2067. "Improvements in automatic electrical circuit switches particularly adapted for use with telephones." C. A. GISBORNE. (Communicated from abroad by F. N. Gisborne and D. H. Keeley, both of Canada.) Dated February 12. 8d. Relates to that class of switching which is operated in the removal of the receiving instrument from, and its restoration to, a certain place or position provided for it in the structure of the associated apparatus.

PROCEEDINGS OF SOCIETIES.

Royal Society, May 27th.

"Researches upon the Self-induction of an Electric Current." By Prof. D. E. HUGHES, F.R.S.

(*Continued from page* 530.)

In the method which I have described, the separation of the extra current from the momentary primary current is so complete that the measures given by the induction balance and resistance slide are invariably the same for a given wire; there is no personal equation, for all observers find precisely the same values both for the resistance and for the extra current.

The method is, however, defective in measuring any small difference of resistance in the variable period in copper wires, as the induction balance itself introduces an additional but opposing resistance by the approaching of its coils, consequently any resistance which we observe is a fraction less than the real amount. To prove this we have only to use a balancing induction current produced from the battery circuit, as shown in my first paper, when we observe this small difference, and better, observe any small difference of resistance in a straight copper wire, and greater when the wire is formed into a coil.

Soft iron wire gives a far higher resistance in the variable period than hard iron, but each wire, according to its molecular structure, has its own value; the effect increases with the diameter, ranging from 25 per cent. increase of resistance for wires of 2 mm. in diameter, to 500 per cent. for those of 6 cm.

TABLE II.—RESISTANCE OF IRON AND COPPER IN THE STABLE AND VARIABLE PERIODS.

Wires, 1 m. in length, 5 mm. in diameter.	Comparative force of the extra current.	Resistance in ohms, stable period.	Resistance in ohms, variable period.	Percentage of increased resistance in variable period.
Copper	78	0·001284	0·001372	7
Soft Swedish iron ...	234	0·008346	0·022200	166
American compound wire, copper exterior, steel interior	83	0·002247	0·002696	20
Ditto, steel exterior, copper interior ...	213	0·007750	0·0248000	220

Table II. shows a few illustrative examples: the resistance is given in the fractions of the ohm, indicated by the resistance slide, M, upon the supplementary resistance wire, H, I.

The table shows that copper and the American compound wire coated with copper have an extremely rapid action or curve from an infinite to its stable resistance, due to their freedom from circular magnetism, whilst iron shows a comparatively slow curve. A remarkable result will be seen where a copper wire has been coated with iron, its variable resistance being 220 per cent. above that of its stable period, and 54 per cent. greater than that of a solid iron wire.

I found in my previous researches that the resistance in the variable period could not be changed by a change in speed of a periodic or tuning fork contact maker, and that the telephone was more sensitive when the rubbing contacts were used without any regard to their frequency of interval. I also found that the telephone was far more sensitive and alone suitable for these experiments when its diaphragm was entirely free from varnish or coating, and sufficiently thick to give a clear musical dominant tone of about C or 512 double vibrations per second, the electro-magnet being also as close as possible without being in actual contact. I noticed that no matter what number of vibrations were sent, the tones given by the telephone on each side of the zero of the bridge were invariably those of its dominant note. Suspecting that the frequency of vibration of the diaphragm had a direct relation with the resistance found, I altered its note through a range of one octave by employing different thickness of diaphragms, and found that the results were in absolute proportion to the frequency of the vibrations of the diaphragm. The highest tone giving a perfect zero with a high resistance in the variable period and the low tone giving its zero at a marked less resistance. Thus it was evident that the telephone selected from the mixed vibrations sent by the transmitter those which alone corresponded to its period of vibration, and that we could thus observe the effect of more or less rapid periodic contacts.

The power which vibrating bodies have of selecting from a confused number of vibrations those in accordance with their own,

is shown in Helmholtz's resonators, and still more as regards electrical waves in the remarkable harmonic telegraph of Elisha Gray, who proved that if the armatures of several electro-magnets are made to vibrate, each with a different musical tone or rate of vibration, then we may by the use of a vibrating transmitter of a fixed rate of speed select the electro-magnet alone whose period of vibrations is similar, and that we may send several different periods of vibrations at the same time without any confusion in the receiving magnets, as each electro-magnet selects from the compound vibrations those in accordance with its own. This is exactly what occurs with a telephone when using a periodic contact maker, but I have found in addition, that a telephone arranged as I have described, will select and respond loudly in its own clear musical dominant tone to a confused mass of rapid contacts such as those produced by a scraping contact, and which in an ordinary telephone gives only the effect of noise, of not one-third the power or loudness of that produced by the tone of the musical telephone. We may thus have ten or more telephones of different musical notes, each responding separately in their own tone or all at the same time, as each diaphragm selects its own period from the confused periods of contacts sent by the scraping contact maker.

In order to verify the results, I have used in these experiments, both periodic and mixed sound transmitters, but find that owing to the difficulty of keeping the periodic transmitter and telephone in perfect tune with each other, that the mixed sound transmitter is preferable, as it gives no trouble whatever, and we have more accurate results, as we then have only to keep our telephones in accord with the number of vibrations desired.

The experiments mentioned in this paper were all made with a fixed note of vibration of the diaphragm of 512 double vibrations per second. I will, however, mention a few made with varying rates of vibration, and as I propose in a future paper to give a more extended series of observations through a wider range, I will confine myself to these examples.

The diagram* shows the results obtained on iron wires of different diameters; their stable and variable resistance were all reduced to comparative values, the stable resistance being taken as 100. Three telephones were employed, the first having the musical note of G or 768 double vibrations, the second C sharp or 576 double vibrations, and the third, one octave below the first or G 384 double vibrations per second.

It will be seen that a great change in the variable resistance takes place in the range of a simple octave, and that the fall from the wires of 6 mm. to that of 1 mm. is so regular as to be almost a continuous curve, and the total curve would be probably that taken by the wire of 6 mm. in its approach to its stable resistance. If this is the case, as future researches may show, then the resistance of this wire with the comparatively slow contact speed of six per second would still have 14 per cent. higher resistance in the variable than in the stable period, or an ordinary Morse telegraph instrument working at a slow speed of only eleven words per minute would experience this additional resistance; consequently this effect should be easy to prove by the ordinary methods with galvanometers, and this can be accomplished as soon as we have found a method of completely separating the extra current from that due to the increased resistance, as I have already succeeded in doing by the method which I have described.

The iron wire of 6 mm. diameter shows for a speed of 384 contacts per second a comparative resistance in the variable period of 638, or more than six times its stable resistance, but with 192 contacts per second its resistance is but 371; the fall of resistance is so rapid here that for a single octave difference in the telephones, the fall is far greater than the whole stable resistance. The extra current, as well known, is proportional to the length of contact for fine wires, but in large wires the curve indicates that the extra currents have a local reaction on the cessation of the primary current.

Influence of a Magnetic Sheath.

The remarkable phenomenon wherein a non-magnetic metal such as copper shows a higher "variable" resistance when under the influence of an external coating of iron than a wire of solid iron (and this notwithstanding that the resistance of the side of the bridge is kept a constant or by balancing its resistance on the opposite side, C, D, as mentioned) seemed worthy of experimental research.

Experiments were made in order to find what form of conductor would give the maximum increased resistance in the variable period, and I found that an external tube of iron insulated from its central core produced this effect, for if the tube was not insulated but joined in electrical contact the results were reduced, due I believe to a transversal neutralisation taking place in its own portion of the wire, as I have mentioned in my reply to the discussion on my first paper.

Table III. shows the effect produced upon an electric conductor by surrounding it with an insulated sheath of iron. It will be seen that the magnetic reaction of the tube upon the primary current passing in the wire produces a marked effect upon the different metals; the force of the extra currents as measured by the induction balance rise in value from 82 to 410, this being a constant for all metals except iron, which alone shows the higher force of 615; the force of the extra currents, however, has no direct relation to the extra resistance shown in the variable period, but the latter must be in direct relation with the duration or length of time required to pass from an infinite to the stable resistance.

* See last week's REVIEW.

TABLE III.—INFLUENCE OF AN IRON TUBE UPON AN INTERIOR INSULATED WIRE.

Iron gas tube, 90 cm. in length, 1·0 cm. diameter, 2 mm. thick. Wires 1 metre in length, 3 mm. diameter.	Comparative force of the extra currents.	Resistance in ohms stable period.	Resistance in ohms, variable period.	Percentage of increased resistance in variable period.	Absolute increase of resistance in ohms.
Copper wire alone	82	0·00460	0·00482	7	0·00022
Copper wire insulated in the interior of the iron gas tube... ...	410	0·00460	0·03220	600	0·02760
Brass wire, ditto	410	0·01380	0·03974	188	0·02594
Iron wire, ditto ...	615	0·02944	0·05888	100	0·02944
Lead wire, ditto...	410	0·05750	0·08682	51	0·02932
German silver wire, ditto ...	410	0·07636	0·10384	36	0·02748

The table shows on comparing the resistance of a metal in its stable period with that found in the variable, that copper has the highest percentage of increased resistance, being 600 per cent. increase, or seven times that found for its stable resistance, each metal in the order of its specific resistance having a less percentage of increased resistance until we arrive at the German silver wire, which shows only 36 per cent. against the 600 per cent. of the copper; we have also here the remarkable fact that iron even with a circular section stands simply in its order of specific resistance, showing only one-sixth of the increased resistance experienced by copper; the percentage of increased resistance of a metal when under the influence of an insulated magnetic sheath is directly as its conductivity or inversely as its specific resistance.

If we regard the phenomenon from a different point of view, confining ourselves simply to the additional resistance above that of its specific stable resistance, all metals whether magnetic or non-magnetic have an almost invariable quantity dependent entirely upon the coefficient of the electro-magnetic action of the iron tube, and independent of the resistance or nature of the wire.

The experiments with an insulated iron sheath may be considered as a forced condition which does not occur or need not be taken into account, but the reaction of the iron tube is evidently electro-magnetic, and as our atmosphere is also magnetic, we may assume that its reaction would be similar though in a far less degree to that which I have shown.

Submarine Cables.

The influence of a magnetic sheath upon an external insulated wire is one of vast practical importance in relation to our electrical submarine cables, as they are all constructed with an insulated wire surrounded by a spiral sheath of exterior iron wires. In order to study this question I made several cables of short lengths (1 metre) and found (most fortunately for our practical applications) that when the exterior iron sheath is divided as in a cable, or when the sheath consists of several large wires in close contact, that its effects are reduced to a mere fraction of what it would be if the external sheath was a continuous tube; this is entirely due (as I have shown in the case of stranded wires as compared with solid) to the imperfect formation of circular magnetism. I will cite a few examples illustrating this: a cable was formed of a similar copper wire and insulation to that shown in Table III., the iron tube being replaced by eight iron wires (of 2 mm. diameter each) wound with a slight spiral of five turns per metre; this showed but 100 per cent. increase in the force of the extra currents against 400 per cent. increase when the same wire was in the iron tube; the increased resistance in the variable period was but 50 per cent. against 600 per cent. for the iron tube, or only one-twelfth of the additional resistance caused by the tubes; these wires were replaced by galvanised iron wire which prevented magnetic contact, and the variable resistance became much less, and when these were replaced by numerous fine iron wires the effect was reduced to the minimum found, or only 20 per cent. increased resistance in the variable period, or 30 times less than that of a solid iron tube of much less iron.

It is therefore evident that the circular magnetism plays an important *rôle*, and that most fortunately our cable manfacturers (without knowing the immense reaction which would be produced by a continuous sheath of iron) have constructed our cables with a protection of iron divided into several iron wires instead of a continuous iron sheath; there are, however, many telegraph lines which in passing through tunnels use a continuous iron tube as the protection, and therefore such lines must feel all the deleterious effects that I have shown to be caused by the reaction of circular magnetism.

Influence of Copper and Iron Cores upon the Induction and Resistance of Coils.

It is well known that a coil of wire has a higher self-induction than the same wire in a single loop, and that the coil has a still higher induction when we introduce an iron core. I have made, however, a series of experiments in order to measure the influence of a core upon the resistance in the variable period, and also note the influence exerted by the induced or eddy currents circulating in the core: the following table shows some comparative results:—

TABLE IV.

Helix formed of insulated copper wire, 1·50 metre in length, 2 cm. diameter, and 24 turns.	Comparative force of the extra currents.	Resistance in ohms, stable period.	Resistance in ohms, variable period.	Percentage of increased resistance in variable period.	Absolute increase of resistance in ohms.
Helix alone ...	460	0·02632	0·02896	10	0·00264
Same with a core of solid copper ...	352	0·02632	0·04013	52	0·01381
Same with a core of insulated copper wire... ...	460	0·02632	0·02896	10	0·00264
Same with a core of solid soft iron	2338	0·02632	0·09870	275	0·07238
Same with a core of 445 separate fine iron wires, each 0·25 mm. diameter ...	5360	0·02632	0·04448	69	0·01816
Same with a core of silk-covered fine insulated iron wires ...	5820	0·02632	0·04075	55	0·01443

A helix was formulated of an insulated silk-covered copper wire of 24 single layers, having an interior diameter of 2 cm., the object being to form a coil having as little mutual induction as possible, but which would be readily acted upon by any core of metal introduced; and in order to measure the high forces obtained an induction balance of great power and range was used, the method, however, being the same as that already described.

The helix alone showed an induction value for its extra currents of 460, and a feeble increased resistance in the variable period of but 10 per cent.; if we now introduce a core of solid copper of 1·75 cm. diameter and 5 cm. long, a great change takes place both in the force of the extra currents and the resistance in the variable period, the extra currents falling in value from 460 to 352, whilst the extra resistance is increased to 52 per cent. above that of the stable period. We have here a double and contrary effect; the reduction of the force of the extra currents and the increase in the resistance cannot be due to the magnetic nature of copper, but must be due to the induced or so-called "Foucault currents" circulating in the core; to prove this the core was replaced by another similar in every respect but cut longitudinally to its centre, the currents now ceased to circulate, and the copper core had not the slightest effect either on the extra currents or the variable resistance; this is shown in the table, where for greater precautions a core of insulated copper wires replaced the solid core. Evidently the induced current in the core was the cause of the extra resistance; work was done by the primary current, and a loss of energy at the expense of the electromotive force of the extra currents, but in doing this work a resistance was produced which was no doubt caused by the currents circulating in the core. These currents required time, passing through the variable stage and thus producing from their electro-magnetic inertia an equivalent reaction and electro-magnetic inertia in the primary coil itself. That this inertia is due to the electro-magnetic character of the current and not to an electric current considered apart, is proved by the fact (which I have verified) that when we coil a wire into a coil of several superposed layers, its electro-magnetic reactions introduce a measurable resistance in the variable period precisely similar though feebler than that which would be produced by the reaction on the conductor of a magnetic body, such as iron.

The effect of a solid iron core and a bundle of iron wires on the increase of the force of the extra currents is well known, but the table shows an interesting result as to their effects on the variable resistance; the solid iron core shows a very high force of extra currents produced by its magnetic reaction on the wires of the helix. The resistance in the variable period has increased 275 per cent., and its extra currents are extremely high, as we should expect; now if the extra resistance is due to magnetic reaction alone it should increase when we are enabled to increase this reaction, but if it is due in greater part to the electro-magnetic inertia of electric currents circulating in the bar, then by preventing these currents from being formed (as we did in the case of copper) we should greatly reduce the extra resistance. This proved to be the case, for on replacing the solid iron core by a bundle of fine iron wires the force of the extra currents rose from 2,338 to 5,360, or more than double the force of that produced by a solid bar, whilst the resistance in the variable period fell from 275 to but 69 per cent.

It is well known that a bundle of fine wires magnetises quicker than a solid bar, and this may have had its effect, although not more important than the suppression of the eddy currents, as the latter may be the cause of the former. The table shows that where we have suppressed these currents as far as possible by introducing a core of insulated wires containing less iron than in the previous experiment, but fully insured against eddy currents, the induction was the highest and the resistance the lowest yet found for a helix containing an iron core; the experiment proves to my mind that the extra resistance found in the three last experiments is due both to the electro-magnetic inertia of the eddy currents, and the inertia of the magnetic molecules of iron.

The experiments related in this paper have been most carefully made and verified, and from the ease and certain action, as well as the invariable results obtained by the method which I have described, they should be easy to repeat by others.

If we regard the whole of these researches we cannot fail to notice certain important laws which act in the greater portion of them. I have shown: 1st. That the contiguous portions of the same current react upon each other in the interior of its own portion of the conductor similar to their known exterior reactions on separate portions of the same conductor. 2nd. That the coefficient of mutual induction is less in iron than copper wires, but that their coefficient is the same when the conductor is in the form of a ribbon. 3rd. That the inductive capacity of different metals depends on their specific resistance, on their electro-magnetic capacity for circular magnetism, and on the geometrical form of their conductors. 4th. That the inductive capacity of a conductor of magnetic metal is dependent upon the formation of circular magnetism, and not upon its internal magnetic permeability. 5th. That a magnetic metal can be rendered equally free from circular magnetism as the non-magnetic metals. 6th. That we have experimental evidence of electro-magnetic inertia and the deleterious effects of eddy currents in the cores of electro-magnets.

In addition to the above effects, we have the discovery of a large increase in the ohmic resistance during the variable period, allowing us to demonstrate and measure the gradual rise of an electric current in its conductor.

In conclusion, I desire to express my warmest thanks to Lord Rayleigh, Mr. F. L. Pope, Prof. Forbes, Dr. Hopkinson, Mr. W. H. Preece, Dr. Fleming, Mr. Fitzgerald, Prof. Silvanus Thompson, and Prof. Ayrton, for the important theoretical contributions they gave on the discussion of my first paper. Mr. W. H. Preece, electrician of the Post Office, not only gave information of great practical value, but has kindly supplied me with the wires used in these experiments. The discussion proved the necessity of the researches which I have undertaken, and the importance of an experimental determination of the self-induction of an electric current in relation to the nature and form of its conductor.

Abstract of a Paper read May 20th.

"On the lifting power of electro-magnets and the magnetisation of iron," by SHELFORD BIDWELL, M.A.

If an electro-magnet be excited by a gradually-increasing current, a limit is soon reached beyond which the ratio of increase of sustaining power to increase of current becomes rapidly smaller, and it has generally been assumed that this ratio continues to diminish indefinitely, so that an infinite current would not impart to a magnet much greater lifting power than that which it possesses when an approach to "saturation" is first indicated. Joule estimated that the attraction could never be as great as 200 lbs. per square inch of sectional area; and much later Rowland assigned 177 lbs. per square inch, or 14,240 grms. per square cm. as the limit for iron of good quality.

Having reason to doubt these conclusions, the author made some experiments with an iron ring cut into two equal parts, each of which was surrounded by a coil containing nearly 1,000 turns of insulated wire. When one half of the ring was used as an electro-magnet, and the other half as an armature (no current being passed through the coil of the latter), the weight supported was, with a current of 4·3 ampères, 13,100 grms.; and, with 6·2 ampères, 14,200 grms. per square cm. of surface. The lifting power, therefore, exceeded that which had previously been considered the greatest possible; nor was there any indication that a limit was being approached. But it was of greater interest to observe the effects produced when *both* portions of the ring were brought under the influence of gradually-increasing currents, the conditions then approximating to those of Rowland's experiments. It was found that when the magnetic force had reached 50 C.G.S. units, at which point the weight sustained was about 10,000 grms. per square cm., the falling off in the rate of increase of the lifting power was well marked. And it continued to diminish until the magnetic force was 250 units, and the weight supported 14,000 grms. *But from this point the magnetising current, and the weight which could be carried, increased in exactly the same proportion,* and continued to do so until the magnetic force had been carried up to 585 units, when the experiment was stopped, the maximum weight supported having been 15,905 grms. per square cm., or 229·3 lbs. per square inch. Detailed results are given in the first and second columns of the table. A curve plotted with the magnetic forces as abscissæ, and the weights lifted as ordinates, becomes, when the magnetic force is greater than 240 units, a sensibly straight line inclined to the horizontal axis.

It occurred to the author that these results might be applied to the investigation of the changes of magnetisation which correspond to changes of magnetic force. For, if W = the grms. weight supported per square cm., H = the magnetic force, and I = the magnetisation, then, for the divided ring,

$$W g = 2 \pi I^2 + H I;$$

and by giving to W and H the values found to correspond, it becomes possible to find corresponding values of H and I. These are contained in the first and third columns of the table. When H has exceeded about 200, the ratio of I to H no longer continues to diminish, and the curve expressing the relation between them apparently becomes an inclined straight line. Were the experiment carried further, a tendency to a limit would perhaps be indi-

cated. But if there is one, it must be considerably higher than it is generally believed to be.

If κ denote the susceptibility, μ the permeability, and B the magnetic induction, then $I = \kappa H$, $\mu = 1 + 4\pi\kappa$ and $B = \mu H$. Hence the values of κ, μ, and B corresponding to values of H can be found. They are given in the last three columns of the table. The figures for μ and B are of great interest. Rowland—in order to exhibit the results of his well-known experiments in the form of a curve which (as he believed) would be of finite dimensions—plotted the values of μ as ordinates against those of B as abscissæ. The curve of μ thus obtained, after reaching a maximum for B = 5000, fell rapidly and in an almost straight line towards the horizontal axis. Assuming that the line would continue to be straight until it actually met the axis, Rowland concluded that the maximum of magnetic induction was about 17,500 units.

Now the greatest magnetic force used in Rowland's experiments was only 64 C.G.S. units: the imaginary part of his curve, therefore, corresponds to values of H ranging from 64 to infinity. A part of this exceedingly wide gap is filled by the author's experiments, in which H reaches 585 units, and if the values of μ and B given in the table are plotted the curve will be found (after a rapid descent) to *bend round* soon after the limit of Rowland's observations, ultimately becoming (when B = 19,800) almost parallel to the axis of B.

The generally accepted ideas as to the limits of magnetisation and magnetic induction, therefore, need-modification.

TABLE (ABSTRACT).

H	W	I	κ	μ	B
3·9	2,210	587	151·0	1899·1	7,390
5·7	3,460	735	128·9	1621·3	9,240
17·7	7,530	1083	61·2	770·2	13,630
30·2	9,215	1197	39·7	500·0	15,100
78	11,550	1337	17·1	216·5	16,880
208	13,810	1452	7·0	88·8	18,470
427	15,130	1504	3·5	45·3	19,330
585	15,905	1530	2·6	33·9	19,820

CORRESPONDENCE.

American Telephone Patents.

I send to the REVIEW the lastest sensation about the Bell Telephone Patent. The substance of the publication is that Mr. Wilber has made an affidavit in which he confesses that he, at that time Chief Examiner of electrical matters, in violation of the rules of the Patent Office, did show to Mr. Alex. G. Bell Gray's caveat, and that Bell gave to Wilber one hundred dollars.

Wilber has before made several affidavits respecting the issuing of Bell's patent of 1876, but this last affidavit contradicts some things in the former affidavits. Wilber explains all this in his affidavit. I send comments on this subject by the editors of the New York *Times*. I regret that I have not time to send you a synopsis of this long statement with my opinion thereon, but I shall send the latter by next steamer.

I send a newspaper containing some account of new discoveries by Bell and others. I think that St. George is ahead of Bell.

W. C. Barney.

Washington, *May 24th*, 1886.

New Patents of Bell and Others.

I send to the REVIEW two of the latest patents issued to Bell and others, and I hope you will have time (for I have not) to carefully examine those patents, especially the patent for "Recording and Reproducing Speech and other Sounds," patent issued May 4th, 1886, for which patents Nos. 6,042 and 6,047 were applied for in England on May 4th inst. in the name of the "Volta Graphophone Company."

The patentees, namely, A. G. Bell, C. A. Bell, and Sumner Tainter have procured a charter in Alexandria, Virginia (a small town some 15 miles from Washington), under the name of "The Graphophone Company," to which company these patents have been transferred (see enclosed newspaper notice). I make notice of this transfer because Prof. A. G. Bell in his testimony before the Investigating Committee of Congress, said that he had sold all his *future* inventions to Hubbard and Saunders. It has been suggested that these latest patents, although the invention of A. G. Bell, have been taken out with other names as inventors so as to avoid the effect of the sale in 1874 to Hubbard and Saunders. I desire particularly to invite your attention to the specification of an instrument "for recording and reproducing through telephonic wires articulate speech," patented by A. F. St. George, a description and drawing of which was published in the REVIEW on October 20th, 1883. I hope you will compare this great invention of St. George with that of the Bells, and perhaps you will find out that these Bells are just as much entitled to this invention as Prof. A. G. Bell is entitled to be the inventor of the speaking telephone.

I enclose an extract from the REVIEW which was taken from another paper and formed the subject of remarks by "Modesty" about St. George's invention. See REVIEW of September 15th, 1883.

A word or two about the words "*tympan, diaphragm*," I thought that the last decision by one of your "*Dogberrys*" touching the signification of those words showed an extent of scientific knowledge not possessed by any other person; but the Examiner-in-Chief of our Patent Office, C. J. Kintner, has given an official written opinion that a *hollow box of metal* is a *diaphragm* or *tympan*. It is advisable that inventors on your side of the water should know what this *scientific* Examiner considers to be a *tympan* or *diaphragm*, I refer them to a patent No. 5,001, 1882, issued in England to G. L. Anders, and I inform them that Mr. C. J. Kintner, principal Examiner in Electricity of the U.S. Patent Office, has rejected an application for a patent for a telephonic transmitter, for the reason that the *tympan*, which is a *thin piece of ferrotype*, is anticipated by the above-cited English patent because in that patent this scientific Examiner holds that a hollow box or *Indiarubber* ball is a tympan. I advise your inventors who wish to use a *tympan* in any instrument for which they might wish to obtain a patent here, to consult the English patent above named.

W. C. Barney.

Washington, *May 29th*, 1886.

[The patents to which our correspondent refers are for improvements in phonographs. We do not see any similarity between these and the patent of Mr. A. F. St. George.—EDS. ELEC. REV.]

Schanschieff's Battery.

There has been some correspondence in your columns lately on Schanschieff's batteries, and as I have tested them several times, will you kindly permit me to give you my experience of them.

The E.M.F. is about 1·4, and remains pretty constant until the solution is nearly exhausted. The zincs require no amalgamation, the battery gives off no fumes; and to give M. Schanschieff the credit justly due to his invention, I believe that his single fluid battery is the best yet produced in respect of space occupied, length of time it works, and E.M.F. The greatest objections seem to be the cost of solution, and the destruction it brings upon terminals and connections more than other solutions, but doubtless this can be remedied to a great extent.

The solution should never be used in any cell or with any elements that have worked with any other solution, or the effects of which Mr. Conry complains will follow, very much to the detriment of the battery. To get a good result, great attention should be paid to cleanliness, a fact which is quite lost sight of by the majority of people using batteries.

A Maker of Primary Batteries.

June 7th, 1886.

The Laws of Magnetism.

Not in any captious spirit, but solely for information, may I venture to ask if it is consistent with the known principles of electricity that a compass should be found serviceable on the exterior of a revolving globe, so that let it be placed wherever it may, it should point to one spot on that spherical surface? May I hope that this question will be answered without any reference to prevailing notions?

John Hampden.

Balham, S.W.

[The magnetic action of a compass needle is in no way affected by motion being given to the compass; it is strictly consistent with the laws of magnetism (permanent or electro) that a compass needle should point towards a magnetic fixed point on a sphere when the latter is revolving.—EDS. ELEC. REV.]

Military Telegraphy.

In reference to Captain Cardew's paper read at the Telegraph Engineers on May 27th last, it may be of interest to point out that others had in 1881 turned their attention to telegraphing with the telephone. There was, in the Italian division of the French Exposition d'Electricité, exhibited a telephone made to buzz by a switch in it, and connected with it a battery, to be carried on the shoulders like a knapsack. I think the exhibit was that in the Catalogue Général Italie (Royaume D), Groupe 1, Classe 7, numbered "1605, Racagui (Charles Félix), Colonel, et Gugliemini (Emile Antoine), Vérone-Telegraphe, télephone de campagne et application du téléphone a la télégraphie." I think the telephone had some mechanism besides the buzzer; but from the mass of electrical novelties I then saw, I cannot say that I remember sufficiently these last.

H. G. Y.

June 7th, 1886.

Long Distance Telephony.

Allow me to make a few remarks concerning the correspondence *re* Long-Distance Telephony that appears in your issue for June 4th.

My own individual experience is in direct contradiction to "Slabee's" statement that the Newcastle Post Office officials are unwilling to show their telephonic arrangements to outsiders, as some time ago I made application for myself and two others interested in telephony to see over the exchange, and, though entire strangers, no objection at all was made, and everything was shown and explained to us with the utmost readiness and courtesy.

"Telephonist" states that during the last year or so the telephone service in London has greatly improved. All I can say is that if this is the case it must have been bad, indeed, before. A sad experience of one day, a few months ago, when I tried for fully half-an-hour to communicate from Northumberland Avenue to Holborn Viaduct, and had eventually to give it up and send a telegram, as owing to the persistency and loudness of the induction noises and the weakness of the telephones, speaking was quite hopeless, makes me think that there still remains considerable room for further progress in the metropolitan telephone system. I believe, moreover, that my experience is by no means an isolated case, as I have heard of many other similar instances of failure.

I may mention for the benefit of A. Watts, "Slabee," and others, that though a constant user of the Newcastle Post Office system, I have never come across a failure of any description; and that the double-wire system employed, though entirely underground, eliminates induction noises and cross talk altogether. In fact, from my own experience, and from what I have heard from others, I have no hesitation in saying that the Newcastle Post Office exchange service is second to none in the United Kingdom.

I believe that this is very largely due to the double-wire underground system, which is not subject to the vicissitudes of wind and weather that affect overhead wires, but also in great measure to the Gower-Bell instruments that are used, which, though perhaps not absolutely quite so distinct in articulation as the Bell-Blake combination, are much louder, and with their double ear-tubes in every respect more suitable for use in offices and other noisy localities.

The Gower-Bell instruments are very substantially put together, and seem to be peculiarly free from the defect of easily getting out of order, which is more than can be said of the others.

A. A. Campbell Swinton.

Newcastle-on-Tyne,
June 7th, 1886.

I am aware that there is no manner of copyright in *Noms de plume*, still I cannot but feel just a little aggrieved that someone has borrowed that of "Telephonist," in order to sing the praises of the existing telephone companies, especially as I emphatically disagree with most of what this someone promulgates.

Permit me to subscribe myself the original

Telephonist.

June 5th, 1886.

I notice the following statement in your answer to several correspondents' letters on the above subject:—"We believe that if application is made in the proper way every facility would be given to an applicant to see the postal telephonic apparatus." Can you kindly tell me which is the proper way to make this application? For my part, as a member of a private company, I am most anxious to visit the Newcastle exchange, after all that has now been said concerning its arrangement and working. You must confess that if a certain number of people who call themselves "we who know" insist upon keeping Mr. Smith in the dark, they can, without fear of contradiction, describe him as being tall, short, ugly or handsome.

Your correspondent "Slabee" states that Mr. Preece has visited several of the private companies' exchanges, then why should members of the private companies be refused admittance to the postal telephone exchanges? Until this state of things is altered the improvements made by postal telegraph engineers must, as far as we (who are not numbered amongst the "knowing few") are concerned, remain a myth. Vast improvements are no doubt required to make telephony what it ought to be, and I certainly think that the more the members of the opposition parties know of each others ideas on the subject, the more likely are the public to benefit by real improvements; and not be told, as at present they are in the Tyneside district, that they have improvements as near perfection as possible in daily use; and when they ask, "What are they?" receive the answer, "Oh, you must leave that to us! 'we who know' say they exist, and therefore it must be true."

I was greatly surprised to see that you referred "Telephonist" to a number of *Punch*, after stating that "you do not expect to see aught but blundering when the *Times* takes in hand anything electrical." What do you expect to see but the ridiculous when *Punch* does so? As a settlement of this somewhat bad-tempered discussion, I should suggest that the Mr. Smith in question be put through his paces in broad daylight, and, perchance, he may turn out to be as perfect a being as described, and then "we who will know" will assuredly give credit where credit is due.

Carnwath.

June 8th, 1886.